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THE PSYCHOLOGY OF DECEPTION.

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THE saying that appearances are deceptive is an inheritance from very ancient times. To Oriental and to Greek philosophers the illusory nature of the knowledge furnished by the senses was a frequent and a fertile theme of contemplation and discussion. The same problem stands open to the psychologist of to-day; but, profiting by the specialization of learning and the advance of technical science, he can give it a more comprehensive as well as a more practical answer. The physiological activities underlying sense-perception are now well understood; the experimental method has extended its domain over the field of mental phenomena; and in every way we have become more expert in addressing our queries to the sphinx, Nature, so as to force a reply. To outline the position of modern psychology with reference to this interesting problem of deception is the object of the present essay.

In a sensation we recognize a primitive element in the acquisition of knowledge. The deprivation of a sense results in a dwarfed and incomplete mental development. This is due, not to the mere sense-impressions that the organ furnishes, but to the perception and co-ordination of these by inferential processes of the higher faculties. It is not the eye of the eagle, but the brain directing the human eye, that gives intellectual supremacy. Physiology recognizes this distinction as one between lower and higher brain-centers. A man may lose his retina, or may have his optic nerve injured, and so be blind in the ordinary sense of the word. He is prevented from acquiring further knowledge by this avenue; but,

unless he become blind in early childhood, he will retain a good memory for visual images, will be able to more or less clearly imagine pictorially the appearances of objects from verbal descriptions, and in the free roamings of his dream fancy will live in a world in which blindness is unknown. On the other hand, cases occur where, owing to the disordering of certain portions of the finely organized cortex of the brain, the patient, though retaining full sight and understanding, is unable to derive any meaning from what he sees. The same group of sensations that suggest to our minds a book, a picture, a face, and all the numerous associations clustering about these, are as unmeaning to him as the symbols of a cipher alphabet. This condition is termed "psychic blindness," and what is there lost is not the power of vision, but of interpreting, of assimilating, of reading the meaning of visual sense-impressions.

In the experiences of daily life we seldom have to do with simple sensations, but with more or less complex inferences from them; and it is just because these inferences go on so constantly and so unconsciously that they are so continually and so persistently overlooked. It has probably happened to the reader that, upon raising a pitcher of water which he was accustomed to find well filled, the vessel has flown up in his hand in a very startling manner. The source of the difficulty was the emptiness of the pitcher. This shows that one unconsciously estimates the force necessary to raise the vessel but only becomes conscious of this train of inference when it happens to lead to conclusions contradictory of the fact. The perception of distance, long thought to be as primitive a factor in cognition as the impression of a color, is likewise the result of complex inferences; and the phenomena of the stereoscope furnish unending illustrations of the variety and complexity of these unconscious reasonings. These, it must be noted, are drawn by all persons alike; but, like the man who was unaware that he had been talking prose all his life until so informed, are not recognized as such until special attention is directed to them.

The simplest type of a deception occurs when such an inference owing to an *unusual disposition of external circumstances*, leads to a conclusion which other and presumably superior testimony shows to be false. A typical case is the observation, described already by Aristotle, that a ball or other round object held between two fingers crossed one over the other, will seem double. Under ordinary circumstances a sensation of contact on the left side of one finger and on the right side of the finger next to it (to the right) could only be produced by the simultaneous application of two bodies. We unconsciously make the same inference when the fingers are crossed and thus fall into error—an error, it is important to observe, which we do not *outgrow* but *antagonize* by

more convincing evidence. Again, the stimulation of the retina is ordinarily due to the impinging upon it of light-waves emanating from an external object. Accordingly, when the retina is disturbed by any exceptional cause, such as a blow or electric shock, we have a sensation of light projected outward into space. In brief, we are creatures of the average; we are adjusted for the most probable event; our organism has acquired the habits impressed upon it by the most frequent repetitions; and this has induced an inherent logical necessity to interpret a new experience by the old, an unfamiliar by the familiar. As Mr. Sully well expresses it, these illusions "depend on the general mental law that when we have to do with the unfrequent, the unimportant and therefore unattended to, and the exceptional, we employ the ordinary, the familiar, and the well known as our standard." Illusion arises when the rule thus applied fails to hold; and whether or not we become cognizant of the illusion depends upon the ease with which the exceptional character of the particular instance can be recognized, or the inference to which it leads be opposed by presumably more reliable evidence.

As our present purpose is to investigate the nature of real deception, of the formation of false beliefs leading to erroneous action, it will be well to note that even such elementary forms of sense-deceptions as those just noted fall under this head. No one allowed the use of his eyes will ever *believe* that the ball held between the crossed fingers is *really* double, but children often think that a spoon-half immersed in water is *really* bent. Primitive peoples believed that the moon *really* grew smaller as it rose above the horizon, and the ancients could count sufficiently upon the ignorance of the people to make use of mirrors and other stage devices for revealing the power of the gods. The ability to correct such errors depends solely upon the possession of certain knowledge, or a confidence in the existence of such knowledge.

Still confining our attention to deceptions produced by exceptional external arrangements, let us pass to more complex instances of them. These, as so many of the types of deception, are found in great perfection in conjuring tricks. When ink is turned into water and water into ink; when a duplicate coin or other article is skillfully introduced in place of the one that has disappeared; when two half-dollars are rolled into one; when a box into which you have just placed an article is opened and found to be empty; when the performer drives a nail through his finger, or when a card which you have just assured yourself is the ace of hearts on second view becomes the king of spades—you are deceived because you are unaware that the addition of a chemical will change the color of liquids; that the piece you now see is different from the one you saw a moment ago; that the one half-

dollar is hollow and the other fits into it; that the box has a double bottom; that the nail has been substituted for one that fits around the finger, and that one half of the card is printed on flap which by falling down shows another aspect. All these are technical devices which amuse us by the ingenuity of their construction and provoke about the same kind of mental interest as does a puzzle or an automaton. Ignorance of this technical knowledge or lack of confidence in its existence may convert these devices into *real deceptions* by changing the mental attitude of the spectator. However, the plausibility of such performances depends so much upon their general presentation that they seldom depend for their effectiveness *solely* upon the objective appearances they present. Asking the reader, then, to remember the very great number and ingenuity of such devices, and insisting once more that the only complete safeguard against being deceived by them is the acquisition of the purely technical knowledge that underlies their success, I will cite in detail a trick combining illustrations of several of the principles to be discussed. A number of rings are collected from the audience upon the performer's wand. He takes the rings back to the stage and throws them upon a platter. A pistol is needed, and is handed to the performer from behind the scenes. With conspicuous indifference he hammers the precious trinkets until they fit into the pistol. A chest is hanging on a nail at the side of the stage. The pistol is fired at this chest, which is thereupon taken down and placed upon a table toward the rear of the stage. The chest is unlocked and found to contain a second chest. This is unlocked and contains a third; this a fourth. As the chests emerge they are placed upon the table; and now from the fourth chest there comes a fifth, which the performer carries to the front of the stage and shows to contain bonbons, around each of which is tied one of the rings taken from the audience. The effect is indescribably startling. Now for the real *modus operandi*. In the hand holding the wand are as many brass rings as are to be collected. In walking back to the stage the genuine rings are allowed to slip off the wand and the false rings to take their places. This excites no suspicion, as the walking back to the stage is evidently necessary, and never impresses one as part of the performance. The pistol is not ready upon the stage, but must be gone for, and as the assistant hands the performer the pistol, the latter hands the assistant the true rings. The hammering of the rings is now deliberately undertaken, thus giving the assistant ample time to tie the rings to the bonbons, and, while all attention is concentrated upon the firing of the pistol, the assistant unobtrusively pushes a small table on to the rear of the stage. This table has a small fringe hanging about it, certainly an insignificant detail, but none

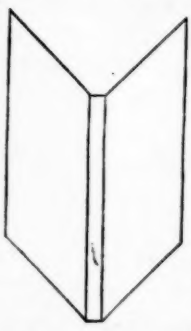
the less worth noting. The chests are now opened, and, after having shown the audience that the second chest comes out of the first, the third out of the second, and so on, he can very readily and quickly draw the last smallest chest from a groove *under* the table and bring it out as though it *had come* out of the next larger chest. This is opened and the trick is done. So thoroughly convinced is the observer by the correctness of his first three inferences that the last box came out of the one before it, that I venture to say this explanation never occurred to one in ten thousand, and that most of the audience would have been willing to affirm on oath that they saw the last box so emerge. The psychology of the process, then, consists in inducing the spectator to draw the natural logical inference, which in this case will be a wrong one.

The more closely the conditions that lead to correct inferences in ordinary experience are imitated, the more successful will be the illusion; and one great principle of conjuring illusions is to *first actually do* that which you *afterward* wish the audience to *believe you have done.* Thus, when coins are caught in mid-air and thrown into a hat, a few are really thrown in; but the others palmed in the hand holding the hat, and allowed to fall in when the other hand makes the appropriate movements. Some of the rings to be mysteriously linked together are given to the audience for examination and found to contain no opening, the audience at once concluding that the rings which the performer retains are precisely like them. In general, to gain the confidence of the person to be deceived is the first step alike in sleight of hand and in criminal fraud.

As we turn from the objective to the subjective conditions of deception, we enter the true domain of psychology; for the most scientific deceiver is he who employs least external aids, and counts most upon his power of captivating the intellect. Just as we interpret appearances by the forms they most commonly assume, so it is our average normal selves that interpret them. A variation in our sense-organs or our judging powers will lead to illusion. The effects of contrast are an apt illustration. Coming from a dark to a light room, the light seems glaringly bright; a hand immersed in hot water and then in lukewarm water will feel the latter as cold; when accustomed to the silence of the country the bustle of the city seems unusually noisy, and so on. Fatigue produces similar results. Fatigue the eye for red, and it sees white light as green; the last mile of a long walk seems the longest; the last hour of a long wait, the most tedious. So long as we recognize our unusual condition and allow for its effects, we are not deceived; but under the influence of emotion this power is easily lost. The delusions of the insane are often misinterpretations of abnormal sensations under the guidance of a dominant

idea. One patient, with abnormal skin-sensibility, believes he is made of glass or stone; another, for similar reasons, believes he has an invisible persecutor constantly at his side. But for the present we will assume that the judging powers do not vary beyond their normal limits.

In every perception two factors contribute to the result. The one is the nature of the object perceived, the other that of the percipient. The effect of the first factor is well recognized, the importance of the second factor is more apt to be overlooked. The sunset is a different experience to the artist from what it is to the farmer; a piece of rocky scenery is viewed with quite different interests by the artist and the geologist. The things that were attractive in childhood have lost their charm, and what was then considered stupid, if noticed at all, has become a cherished hobby. Even from day to day our interests change with our moods, and our views of things brighten with the weather or the good behavior of our digestive organs. Not only will the nature of the impression change with the interests of the observer, but even more, *whether or not* an object will be *perceived at all* will depend upon the same cause. The naturalist sees what the stroller entirely overlooks; the sailor detects a ship in the distant horizon where the landsman sees nothing; and this is not because the naturalist and the sailor have keener vision, but because they know what to look for. Whenever an impression is vague or an observation made under poor conditions, this subjective element comes to the front. The vague and changing outline of a cloud is "almost in shape of a camel," or "like a weasel," or "like a whale." Darkness, fear, any strong emotion, any difficulty in perception show the same thing. "La nuit tous les chats sont gris." Expectation, or expectant attention, is doubtless the most influential of all such factors. When awaiting a friend, any indistinct noise is readily converted into the rumbling of carriage-wheels; the mother hears in every sound the cry of her sick child. After viewing an object through a magnifying-glass, we detect details with the naked eye which escaped our vision before. When the answer in the book happens to be wrong, nine tenths of the students will be able to get it none the less. We can regard the accompanying outline either as a book with the back protruding toward us or receding from us. Everywhere we perceive what we expect to perceive, in the perception of which we have an interest. The process that we term sensation, the evidence of the senses, is dual in character, and depends upon the eyes that see as well as upon the things that are seen.



Accordingly, the conjurer whose object it is to deceive does so by creating an interest in some unimportant detail, while he is performing the real trick before your eyes without your noticing it. He looks intently at his extended right hand, involuntarily carrying your eyes to the same spot while he is doing the trick with the unobserved left hand. The conjuror's wand is extremely serviceable in directing the spectator's attention to the place where the performer desires to have it.* So, again, when engrossed in work, we are oblivious to the knock at the door or the ringing of the dinner-bell. An absent-minded person is one so entirely "present-minded" to one train of thought that other impressions are unperceived. The pickpocket is psychologist enough to know that at the depot, the theatre, or wherever one's attention is sharply focused in one direction, is his best opportunity for carrying away your watch. It is in the negative field of attention that deception effects its purpose. Houdin gives it as one of his rules never to announce beforehand the nature of the effect which you intend to produce, so that the spectator may not know where to fix his attention. He also tells us that whenever you count "*one, two, three,*" as preliminary to the disappearance of an object, the real vanishing must take place before you say "three," for the audience have their attention fixed upon "three," and whatever is done at "one" or "two" entirely escapes their notice. The "patter" or setting of a trick is often the real art about it, because it directs or rather misdirects the attention. When performing before the Arabs, Houdin produced an astounding effect by a very simple trick. Under ordinary circumstances the trick was announced as the changing of the weight of a chest, making it heavy or light at will. The mechanism was simply the attaching and severing of a connection with an electro-magnet. To impress the Arabs, he announced that he could take a man's strength away and restore it again at a moment's notice. At one time the man could raise the chest with ease, but the next he would not have power enough to move it an inch. The trick succeeded as usual, but was changed from conjuring to sorcery—the Arabs declaring him in league with the devil.

The art of misleading the attention is recognized as *the* point of good conjuring, the analogues of the diplomacy that makes the object of language to conceal thought; and a host of appropriate illustrations might be derived from this field. The little flour-

* "Again, a mere tap with the wand on any spot, at the same time looking at it attentively, will infallibly draw the eyes of a whole company in the same direction"—*Houdin.* Robert Houdin, often termed "the king of the conjurers," was a man of remarkable ingenuity and insight. His autobiography is throughout interesting and psychologically valuable. His conjuring precepts abound in points of importance to the psychologist, and a reference to his writings will well repay the reader.

ishes, tossing an object up in the air, "ruffling" or "springing" a pack of cards, a little joke—all these create a favorable opportunity, a "temp," when the attention is diverted and the other hand can reach behind the table or into the "pocket." These points would lead us too far, and perhaps it will suffice to analyze the points of interest in the "chest and ring trick" described above. Here the moment for the exchange of the rings is the one which is least suggestive of being a part of the performance, and therefore least attended to. The preparations for the shooting absorb the attention and allow the introduction of the small table at the rear to pass unnoticed; while the series of drawings of the chests so entirely prepare the spectator for the appearance of the last chest from the one preceding, that he actually sees the chest emerge from where it never was.

There is, however, one important factor lacking in the conjurer's performance to completely illustrate the psychology of deception. It is that the mental attitude of the observer is too definite. He knows that he is being deceived by skill and adroitness, and rather enjoys it the more he is deceived. He has nothing at stake, and his mind rests easy without any detailed or complete explanation of how it was done. Quite different must have been the feeling of the spectator before the necromancer of old, in whose performance was seen the evidence of secret powers that could at a moment's notice be turned against any one to take away good luck, bring on disease, or even transform one into a beast. When magic spells and wonder-working potions were believed in, what we would now speak of as a trick was surrounded with a halo of awe and mystery by the sympathetic attitude of the spectators. The most complete parallel to this in modern times is presented by the physical phenomena of spiritualism.* This is a perfect mine for illustrations of the psychology of deception, and it is this that I will consider as the final topic in this cursory view.

The first general principle to be borne in mind is that the medium performs to spectators *in doubt* as to the interpretation to be placed upon what they see, or more or less determined to see in everything the evidence of the supernatural. This mental attitude on the part of the spectators is *worth more to the medium* than any facts in the performance. The difference between such a presentation and one addressed to persons cognizant of the conjuring element in the performance, and bent upon its detection,

* For the present purpose it is necessary to select only such spiritualistic phenomena as have conclusively been proved to be producible by trickery, and to have been accepted as evidences of spiritual agency, without disposing of the problems of spiritualism in the least. Personally, I believe all the phenomena explicable by the same physical and psychological principles that have divested so many of them of their mystery.

can not be exaggerated. It is this that makes all the difference between the *séance* swarming with miracles, any one of which completely revolutionizes the principles of science, and the tedious dreariness of a blank sitting varied only by childish utterances and amateurish sleight of hand. Scientific observers often report that the very same phenomena that were utterly beyond suspicion in the eyes of believers, are to unprejudiced eyes so apparent "that there was really no need of any elaborate method of investigation"; close observation was all that was required. Again, Mr. Davies, of the English Society for Psychical Research, has experimentally shown that, of equally good observers, the one who is informed of the general *modus operandi* by which such a phenomenon as "slate-writing" is produced, will make much less of a marvel of it than one who is left in doubt in this regard.

With these all-powerful magicians, an expected result, and the willingness to credit a marvel clearly in mind, let us proceed from those instances in which they have least effect up to the point where they form the chief factor. First come a host of conjuring tricks performed on the stage in slightly modified forms, but which are presented as spiritualistic. So simple a trick as scratching a name on one's hand with a clean pen dipped in water, and then rubbing the part with the ashes of a bit of paper containing the name, thus causing the ashes to cling to the letters formed on the hand and reveal the mystic name, has been offered as a proof of spirit agency. Whenever an article disappears or rapidly changes its place, the spiritualist is apt to see the workings of hidden spirits; and over and over again have the performances of professional conjurers been declared to be spiritual in origin in spite of all protest from the conjurers themselves. Here everything depends upon the possession of certain technical knowledge; judging without such knowledge is apt to be mere prejudice. Another very large class of phenomena consists of those in which the performer is placed in a position apparently inconsistent with his taking any active part in the production of the phenomena—rope-tying tests, cabinet *séances,* the appearance of a "spirit-hand" from behind a screen, locking the performer in a cage, sewing him in a bag, and so on. The psychologist has very little interest in these; their solution depends upon the skill with which knots can be picked, locks unfastened, and the other devices by which security can be simulated. The chief interest in such performances is the historical one, for these have done perhaps more than anything else to convince believers of the truth of spiritualism. Here, where everything depends upon the security of the fastenings (for once free, the medium can produce messages from the spirit-land limited only by his ingenuity and boldness), it might be supposed that all possible precautions had been taken against undoing

them; while, as a matter of fact, the laxity of most investigators in this regard is well known. These performances deceive because people overlook the technical acquisitions needed to pronounce upon the possibility or impossibility of a fastening being undone and apparently restored without detection. If manufacturers of safes were equally credulous, and gave equally little time to the study of the security of locks, "a safe" would be an ironical expression indeed.

Passing next to the most interesting of spiritual manifestations, those in which self-deception comes to the foreground, I need hardly dwell at length upon the tilting of tables, the production of raps by movements of which the sitters are unconscious; for these have been so often and so ably presented that they must now be well understood. Suffice it to say that it has been objectively proved that it is almost impossible not to give some indication of one's thoughts when put upon the strain; and that, when excited, these indications may be palpably plain and yet remain unperceived by the individual who gives them. The extreme subtlety of these indications is met by the unusual skill of the professional "mind-reader," who takes his clew from indications which his subject is "absolutely confident he did not give." The assurance of sitters that *they know* they did not move the table is equally valueless, and here nothing but objective tests will suffice. The most wholesome lesson to be derived from the study of these phenomena is the proof that not all our intentions and actions are under the control of consciousness, and that, under emotional or other excitement, the value of the testimony of our consciousness is very much weakened. Again, it is almost impossible to realize the difficulty of accurately describing a phenomenon lying outside the common range of observation. Not alone that the knowledge necessary to pronounce such and such phenomenon impossible of performance by conjuring methods is absent, but with due modesty and most sincere intentions the readiness with which the observing powers and the memory play one false is overlooked. In the investigation of Mr. Davies, above referred to, the sitters prepared accounts of the "slate-writing" manifestations they had witnessed, and described marvels that they had not seen but which they were convinced they had seen—writing on slates utterly inaccessible by Mr. Davies, and upon slates which they had noticed a moment before were clean. The witnesses are honest; how do these mistakes arise? Simply a detail omitted here, an event out of place there, an unconscious insertion in one place, an undue importance to a certain point in another place—nothing of which any one need feel ashamed; something which it requires unusual training and a natural bent to avoid. The mistake lies in not recognizing our liability to such error.

If, however, the spectator is once convinced that he has evidence of the supernatural, he soon sees it in every accident and incident of the performance. Not only that he overlooks natural physical explanations, but he is led to create marvels by the very ardor of his sincerity. At a materializing *séance* the believer recognizes a dear friend in a carelessly arranged drapery seen in a dim light. Conclusive evidence of the subjective character of such perceptions is furnished by the fact that the same appearance is frequently recognized by different sitters as the spiritual counterpart of entirely different and totally dissimilar persons. A "spirit-photograph" is declared to be the precise image of entirely unlike individuals. Each one sees what he expects to see, what appeals to his interests the most intensely. What the unprejudiced observer recognizes as the flimsy, disguised form of the medium, the believer transforms into the object of his thoughts and longings. Only let the form be vague enough, the light dim enough, the emotions upon a sufficient strain, and that part of perception in which the external image is deficient will be readily supplied by the subjective tendencies of each individual. In the presence of such a mental attitude the possibilities of deception are endless; the performer grows bolder as his victim dispenses with tests, and we get scientific proofs of the fourth dimension of space, the possibility of matter passing through matter, the laws of gravity entirely set aside. And the identically same performance that would convince Prof. Zoellner of the reality of the fourth dimension of space, would show the spiritualist the workings of his deceased friends, would convince the theosophist of the spiritual flight of the performer's astral body, and (it may not be irrelevant to add) it is the same type of performance that served and yet serves to terrify the minds of uncultivated and superstitious savages. All depend not upon what is done, but upon the mind of the spectator. Little by little, through neglect, through mal-observation and lapses of memory, through an unwillingness to mistrust the reports of an excited consciousness, caution is abandoned, credulity enters, until mediums are actually seen flying out of one window and into another, until the wildest and most far-fetched fantastic explanation is preferred above a simple one; until the bounds of the normal are passed, real hallucinations set in, conduct becomes irrational, and a state not distinguishable from insanity ensues. If this seems improbable, turn back to the records of witchcraft persecutions and read upon what trifling and wholly imaginary evidence thousands of innocent lives were sacrificed; and this not by ignorant, bloodthirsty men, but by earnest, by eminent, by religious leaders. A child is taken sick, is remembered to have been fondled by an old woman; therefore the woman has put the child under a spell and must be

burned. A man sees an old woman in the woods, and, on turning about, the old woman is gone and a hare flies across his track; he concludes that she turned herself into a hare, and the witch test is applied. When the personal devil was believed in, he was daily seen clothed in the garments that imagination had given him, and engaged in mischievous actions of all kinds. When witchery was the dominant superstition, all things gave evidence of that. With the doctrines of modern spiritualism to be supported, the number of mediums and manifestations will be correspondingly abundant. Create a belief in the theory, and the facts will create themselves.

In the production of this state of mind a factor as yet unmentioned plays a leading *rôle:* it is the power of *mental contagion.* Error, like truth, flourishes in crowds. At the hearth of sympathy each finds a home. The fanatical lead, the saner follow. When a person of nervous temperament, not strongly independent in thought and action, enters a spiritualistic circle, where he is constantly surrounded by confident believers, all eager to have him share their sacred visions and profound revelations, where the atmosphere is replete with miracles and every chair and table may at any instant be transformed into a proof of the supernatural, is it strange that he soon becomes one of them?—hesitatingly at first, and perhaps yet restorable to his former modes of thought by the fresh air of another and more steadfast mental intercourse, but more and more certainly and ardently convinced the longer he breathes the *séance* atmosphere. No form of contagion is so insidious in its onset, so difficult to check in its advance, so certain to leave germs that may at any moment reveal their pernicious power, as a mental contagion—the contagion of fear, of panic, of fanaticism, of lawlessness, of superstition. The story of the witchcraft persecutions, were there no similar records to deface the pages of history, would suffice as a standing illustration of the overwhelming power of psychic contagion. To fully illustrate its importance in the production of deception would require an essay in itself. It enters at every stage of the process and in every type of illusion. It has least effect when deception is carried on by external arrangements, by skillful counterfeits of logical inferences; its power is greatest where the subjective factor in deception is greatest, more particularly in such forms of deception as have been last described.

In this review of the types of deception, I have made no mention of such devices as the gaining of one's confidence for selfish ends, preying upon ignorance, upon fear, acting the friend while at heart the enemy, planned connivance and skillful plotting, together with the whole outfit of insincerity, villainy, and crime. It is not that these are without interest or are unrelated to the

many types of deception described, but that they are too complicated and varied to be capable of rigid analysis: the moment deception becomes conscious, there must be acting and subterfuge to maintain the appearance of sincerity. If we add this great class of deceptions to those already enumerated, we may perhaps realize how vast is its domain, and what a long, what a sad chapter would be necessary to contain the history of human error.

Ethics is so closely related to psychology—right knowing to right doing—that a brief "*hæc fabula docet*" by way of summary may not be out of place. We find, first, a class of sense-deceptions which are due to the nature of sense-organs, and deceive only so long as their true nature remains unknown. These are neither pernicious nor difficult to correct. Next come a class of deceptions that deceive because we are ignorant of the possibilities of conjuring and pronounce upon the possibility or impossibility of a certain explanation in advance of complete knowledge; of this I have already said enough. But most dangerous and insidious are the deceptions in which self-deception plays the leading *rôle*. The only safeguard here is a preventive: the thorough infusion of sound habits of thought, a full recognition of the conditions under which the testimony of consciousness becomes doubtful, an appreciation of the true value of objective scientific evidence, and an inoculation against the evils of contagion by an independent, unprejudiced logical schooling. When once these evils of self-deception, fed by the fire of contagion and emotional excitement have spread, reason has little control. As Prof. Tyndall tells us, such "victims like to believe, and they do not like to be undeceived. Science is perfectly powerless in the presence of this frame of mind . . . . It [science] keeps down the weed of superstition, not by logic, but by slowly rendering the mental soil unfit for cultivation." With the spread of education, with the growth of the capacity to profit by the experiences of others, with the recognition of the technical requisites that alone qualify one for a judgment in such matters, with a knowledge of the possibilities of deception and of the psychological processes by which error is propagated, the soil upon which spiritualism and kindred delusions can flourish will be rendered unfit.

THE French Academy of Sciences recently had a discussion about the "Canals" of Mars. A paper by M. Fizeau remarked upon the resemblance between some drawings of these objects and M. Nordenskiöld's view of the great Icelandic glacial crevasse in Greenland as indicating that the whole surface of Mars is covered, down to the equator, with a glacial ice-cap. M. Janssen thought that they were rather crackings resulting from the advanced planetary age of Mars, with excessive cooling and absorption of the oceans and atmosphere, or crevasses in the rocky crust corresponding with the furrows of the moon.

NEW LIGHT ON A LUNAR MYSTERY.

By GARRETT P. SERVISS.

EVERY possessor of a telescope knows that among the mountains of the moon there are some to which the name of "shining mountains" seems peculiarly applicable. The most celebrated of these is the huge extinct volcano Aristarchus, the slopes of whose crater possess such extraordinary reflective power that it is visible on the night-side of the moon by virtue of the comparatively faint light received from the earth. Another famous bright mountain on the moon is Proclus, which rears its crest high above the eastern shore of the so-called Crisian Sea. With a telescope I have seen Proclus glittering above the brownish plains surrounding it, in the middle of a summer afternoon, when, to the naked eye, the moon appeared as a faint silvery disk, half blended with the blue of the sky. There are other natural features of the moon's surface which shine with extraordinary brightness, the most conspicuous being the systems of long "rays," radiating from such crater-rings as Tycho and Copernicus.

But in addition to these long-known and easily recognized objects, there have occasionally been seen upon the moon certain bright points, which are even more curious and mysterious than the shining mountains. The earliest observation of this kind appears to have been made by Herschel in 1783. It was repeated by him in 1787, when he did not hesitate to report, in a communication to the Royal Society, that he had discovered three lunar volcanoes in a state of eruption. Astronomers have been considerably puzzled ever since to account for Herschel's statement. Nobody could question the accuracy of his observation, so far as the power of his telescope enabled him to carry it. At the same time, few, if any, especially in recent times, were willing to admit that that prince of telescopists had really seen volcanoes in action upon the moon. The complete absence of any evidence that volcanic activity did not cease upon our satellite ages upon ages ago militated too strongly against Herschel's assertion. The general conclusion finally was, that Herschel had been misled by the extraordinary brightness of some of the shining mountains which I have just described. It remained almost the only serious blot upon Herschel's record as an observer. He had described the appearance of the supposed eruption too carefully to admit any question as to his meaning. And yet, it seemed, a mere tyro in astronomical observation could hardly be deceived in such a manner, much less the most famous astronomer of his time.

But just now new light has been thrown upon the mystery,

and it comes from that center of astronomical interest, the Lick Observatory. Prof. Holden believes that he has discovered, if not one of the same objects described by Herschel, a phenomenon of the same kind. It is hardly necessary to say that Prof. Holden has not discovered a lunar volcano in action, but the extraordinary appearance that he has seen sufficiently accounts for Herschel's mistake. It will be best to quote the Lick Observatory director's own words from his letter on the subject to "The Observatory," an English astronomical journal:

"I have never been able to understand how Herschel, the keenest of observers, could have been deceived in this observation until the night of July 15th of this year, when I was looking at the moon with the great telescope. At the southern extremity of the Alps, in the dark portion of the disk, not far from the terminator, I saw an illumination of the crest of a high peak which was extraordinarily and incredibly bright. . . . No part of this illumination seemed less bright than a first-magnitude star, and, taken altogether, it was the brightest object I have ever seen in the sky. It was apparently ten times as bright as neighboring portions of the moon's surface. Its yellow light was tinged in places with the purple due to the secondary spectrum of the objective; and, viewed as a whole, it presented the appearance of a vast conflagration—something quite foreign to the brilliant white of the rest of the moon's surface.

"It would have required no stretch of the imagination to have supposed it to be a tremendous eruption of a range of lunar volcanoes. . . . Observations on this and the succeeding nights showed that it was in fact due to a specially brilliant and favorable illumination of a mountain-ridge near the southern termination of the lunar Alps.

"I have now no doubt that the observation of Sir William Herschel referred to similar appearances."

Prof. Holden then refers to a similar, though less brilliant, display that was witnessed in 1843 by Dr. Gerling, of Marburg, apparently at the same spot on the moon.

I may add that there are at least two other recorded apparitions of this sort which were seen in that neighborhood, but evidently not in exactly the same place. The first was observed by Schroeter, the German selenographer, in 1788. He saw in the shadow of the great range of the lunar Alps, at the eastern foot of the mountains, a bright point, as brilliant as a fifth-magnitude star, which disappeared after he had watched it for fifteen minutes. Subsequently, when the region where this light appeared had become fully illuminated by the rising sun, Schroeter perceived, where the light had been, a round shadow on the surface of the moon, which was sometimes gray and sometimes black.

Nothing more was ever seen of the light, so far as any record informs us, until 1865, when Grover, an English observer, caught sight of it again, under circumstances similar to those of its first apparition, and watched it for half an hour, when it once more disappeared. It should be said that, in the case of Dr. Gerling's observation, referred to by Prof. Holden, a "small, round, isolated, conical mountain" was found in the place where the light had been, on the evening following its appearance. It is altogether probable that the gray or black spot perceived by Schroeter was the shadow of a similar mountain, for it is well known that some of the lunar mountains and hills are hardly visible at all except when lateral illumination indicates their position and form by means of the shadows.

Herschel thought he had seen three active volcanoes. If Prof. Holden's discovery accounts for one of these, it is possible that the observations I have just described may give a clew to the others. The phenomenon seen by Schroeter and Grover was located fifty or sixty miles north of the point where Prof. Holden beheld the extraordinary blaze of light last July, and at a point where the mountains, drawing around a culminating peak, confront with tremendous buttresses the broad level of the Mare Imbrium.

The objection has been made by Messrs. Elger and Williams, two competent English observers, that Herschel's volcanoes can not be identical with the glittering peaks seen by either Holden or Gerling, because the latter were observed close to the line of sunrise, where the morning rays touched them, while the phenomena that attracted Herschel's attention were situated far within that part of the disk where the only light came from the earth. But Prof. Holden does not say that the illumination he witnessed was identical in *place* with those recorded by Herschel, but simply that it was identical in *kind*. Besides, it must be remembered that, if these luminous appearances are due to peculiar angles of reflection, a similar effect must be produced whether the reflecting surfaces are presented to the sunlight or only to the earth-shine. The difference would be simply in the degree of brightness of the phenomena.

But while the discovery with the Lick telescope may account for Herschel's mistake, it does not clear up the mystery of the cause of these extraordinary lights. In every case quoted above, the illumination was evidently very much greater than that of Aristarchus, the most brilliant of the shining mountains. Proctor estimated that the reflective power of Aristarchus must be equal to that of new-fallen snow. But the mountain-crest observed by Prof. Holden blazed with a dazzling brilliancy that it would be difficult to account for except upon the theory that nearly all of the sunlight falling upon it was reflected to the ob-

server's eye. Reflection at a particular angle from vast sheets of ice, as smooth as glass, might be suggested as the cause of such a display, but how could ice be there without water or atmosphere? The suggestion that has been offered to account for the brightness of Aristarchus and the "ray" systems, namely, that they are composed of metallic dikes and masses which, for various reasons, have escaped oxidation, is recalled by the phenomenon in question. Upon that view we might have to assume that these luminous points indicated the existence of tremendous crystallized masses, with polished surfaces, throwing back the glare of the sunshine like mirrors. But then we should not be far from the view set forth in Richard Adams Locke's celebrated "Moon Hoax," that some of the glittering eminences on the moon are nothing less than enormous quartz-crystals, whose dimensions are measured by miles instead of inches!

The fact that the apparitions of extraordinary luminosity are confined to comparatively very small areas, and are visible only for a short time and at long intervals, must be taken as an indication that the reflecting surfaces to which they are due must be of such a nature, and so disposed, that they can reflect the sun's light to us only when presented at a particular angle to our line of sight; just as a piece of looking-glass, exposed to the sun at a distance, suddenly darts a piercing ray when the eye comes within the plane of reflection. That these surfaces are the flanks of mountains is in the highest degree probable, and this but serves to heighten the impression of their extraordinary nature.

The rapid appearances and disappearances, and the long periods of invisibility, are readily accounted for by the various librations of the moon, whereby it presents its disk to us at a continually varying angle, as it swims along in its "squirming orbit," under the conflicting attractions of the sun and the earth.

THE place of drawing in the formative system of education is defined by Mr. W. Cave Thomas as that of the gymnastics of the sense of sight. It doubtless held a similar place among the Greeks, who, taking a lesson from the success of the formative training in their athletic games, perceived that the gymnastical system might be applied not only to the proportionate development of the body, but also to the joint development of all the faculties, and to that of the sense of sight, by the practice of drawing. Instead, however, of applying so good an example, our systems of education tend to destroy the true proportions of the faculties by cramming all sorts of knowledge into the brain. Educationists seem to forget that their object should be to promote the power of using knowledge rather than the accumulation of great stores of information. The acquisition of every new element of knowledge is equivalent to the expenditure of a certain amount of vital force, and every addition of new studies leads toward the verge of nervous power. The true object of education should be, while giving the student power to utilize any kind of knowledge, still to leave him with a working margin of vital energy.

THE PINE-TREE LIZARD.

By CHARLES C. ABBOTT, M. D.

ON the outskirts of the quaint little village of May's Landing, N. J., there is seen that rare object, an abandoned railroad. Starting near this place, and running eastward for a distance of some six miles, is a single track, laid upon a substantial road-bed of gravel, and extending through typical Jersey pine-barrens and cedar-swamps. For several years not a car has passed over the rails, which, left to nature, have grown nutty-brown with rust, and often concealed by luxuriant growths of false ipecac (*Euphorbia ipecacuanhæ*), great circular mats of deep purple or pale-green foliage, for such is the freak of the plant to vary thus in color.

When I visited this spot late in May, 1887, the charm of the abandoned railroad was rivaled by the beauties of the surroundings. The glistening snow-white sands were thickly starred with golden Hudsonia; the creek's banks, weighted with densest foliage, brilliant with sarracenia in the height of its glory, and everywhere the more modest grasses gave way to sparkling sun-dews. One knew not where to turn, so crowded were the spot's enticing features, and the rambler was likely to return empty-handed, as is so apt to be the case where attractions are spread out in bewildering profusion. Wondering what novelties might be in store as I passed the outlying traces of the village, I soon found my progress suddenly and effectually stayed—I had reached the tottering, crumbling trestle over Babcock's Creek. Here the gray lizards found a most congenial home, and the peculiar locality offered every reasonable facility for studying them. A long-desired opportunity was at last mine, and birds and botany were no longer thought of.

PINE-TREE LIZARDS (*Sceleporus undulatus*).

This pretty creature, known as the gray or pine-tree lizard (*Sceleporus undulatus*), is also, in many localities, called the "brown swift"; and this seems a most appropriate name, as we read the remarks of Holbrook, De Kay, and of Alexander Wilson, on the habits of the creature. For instance, the last named, in his "Ornithology," expresses surprise that a sharp-shinned hawk should have captured one, "as lightning itself seems scarce more fleet than this little reptile." I was not prepared, therefore, to

find the "swifts" on the trestle anything but swift. It was by hiding, and not through speed, that they sought to escape, and it proved comparatively easy to capture them with the unaided hand. Often they played bo-peep merely around the timbers, and were readily surprised, so that they ran into one hand as they avoided the other. This proved to be the case, also, when I searched for the lizards in the pine-woods, which were as readily captured when up on trees as were those on the trestle.

The village boys adopted ordinarily the simple plan of using a thread-noose placed at the end of a short stick. Dropping the noose gently about the neck of the lizard, they lifted the creature slightly, when its struggles at once tightened the thread and made it a prisoner. It was a favorite pet with the children, and, when I asked some of them if it ever bit or snapped at their fingers, they were greatly amused. I lay stress upon this point, because of the rather widely spread opinion that these lizards are venomous. It is one with the equally absurd impression, due to ignorance and belittling prejudice, that all our snakes are harmful; but a curious feature in this case is the fact that the impression of the lizard being venomous obtains in inverse ratio to the abundance of the animal. Where exceedingly rare, the lizard is dreaded; while, where abundant, as at May's Landing, it is a favorite pet with the children.

Probably a closer study of animal life would materially reduce the list of species supposed to be harmful by those who see but little and know absolutely nothing about them, and put an effectual check upon those who, taking advantage of the ignorance of their audiences, assert deliberate falsehoods, because more entertaining than the simple truth.

As is well known, the pine-tree lizard is quite sensitive to low temperatures. It does not make its appearance in southern New Jersey earlier than May, nor remain abroad later than September. Of course, this is a general statement, and only approximately true, as all such statements must be. Perhaps there can be found nothing more absurd in scientific literature than the frequent *ex-cathedra* statements—for instance, concerning the movements and range of our birds, as though the latter recognized any other law than that of their own convenience and fancy.

At May's Landing I found the lizards sensitive even to the ordinary variations of temperature of average summer days, observing that, whenever it was cloudy, they were far less abundant, and actually sluggish. On the other hand, the extreme degree of heat to which they are willing to expose themselves is not a very high one, judging from the actions of a large number kept in confinement.

Fifteen adult lizards were placed in an inclosure in which

every prominent feature of their homes was reproduced. I found that at 120° Fahr., with the atmosphere perfectly still, they invariably sought shelter, clustering in one cooler and dark corner; but at 100° they were exceedingly active, particularly if hungry, and made no effort to avoid the direct rays of the sun.

When exposed to a sudden transition from a very high to a low temperature, they quickly became inert, and, as the warmth was allowed to increase, it was instructive to see the sluggish movements of both the lizards and the imprisoned flies give way to more active ones, which culminated in the restored suppleness of the reptiles being equal to the capture of the swiftly darting insects. Forced exposure, for a period of three hours, to a temperature of 135°, caused death in four instances, and brought about a condition akin to æstivation in nine specimens thus exposed. As the pine-tree lizards are always found in localities where there is adequate shelter from excessively high temperature, it is not probable that æstivation ever occurs, as it does occasionally among some of our wild mice; but it is interesting to note that a condition closely allied to it can be artificially produced.

The conclusion reached by both field observation and experiments was, in brief, that when the temperature is such that those forms of insect life upon which they depend become inactive, the lizards withdraw to their shelters and likewise remain quiet if not asleep, this period of inactivity extending over several days, as during the prevalence of a northeast storm, or a protracted "spell" of cool and cloudy weather. Again, experiments with a large number in confinement showed that when kept without food at a low temperature, they lived for many days, while a like number starved in a short time when a high temperature was maintained. This lizard, therefore, appears to be one originally belonging to a tropical climate, that has gradually become adapted to a temperate and variable one.

The normal coloring of the pine-tree lizard is distinctly protective. Whether this has been gradually acquired or not, it is certain that it now renders the animal quite inconspicuous. Particularly when it is resting upon a rough-barked tree is this true; and one of my first objects, in studying the species in its native haunts, was to determine how far the markings were changeable and under their owner's control. Many specimens were found tc be quite dark—indeed, almost black—while others were so light that the undulating transverse bars upon the back were very distinct and discernible at a considerable distance. This difference, I am quite sure, bore no relation to the surroundings; and the specimens subsequently collected and kept under daily observation for nine weeks practically retained the light or dark coloring they possessed at the time of capture. In confinement many

individuals remained of a light color under all circumstances; others, that were dark when received, became light for brief periods, but were very dark fully ninety-five per cent of the time they were under observation.

The long and broad glistening green markings upon each side of the abdomen are equally variable, certainly not a distinction of sex, as suggested by Le Conte and Say, and often absent for weeks in specimens which occasionally exhibited them in all their brilliancy.

In no instance was there that prompt change of hue that we see in the tree-toad (*Hyla versicolor*), and even more so in the wood-frog (*Rana sylvatica*). The change in the latter is as abrupt and complete as in certain fishes, and is particularly significant, inasmuch as it is the only frog that needs protective coloring, living as it does in woodland tracts, where it is exposed to an abundance of enemies: and may it not be that, by its power to adapt itself to the general color of the surroundings, it renders itself inconspicuous to the insects upon which it preys? If so, the control over its color becomes doubly advantageous.

Vision in the pine-tree lizard is apparently not very acute, although the eyes are exceedingly bright, and, when coupled with certain movements of the head, suggest considerable intelligence. It was found very difficult to test their visual powers, although, once captured, these lizards became extremely tame, patient, and obedient, and I could only infer that the sense of sight was none of the best from the fact that when held to a mosquito-frame in a window, upon which house-flies were walking, they missed fully one half of those at which they snapped; and other lizards in confinement, but where every possible freedom of movement was practicable, often made many attempts to capture flies before success crowned their efforts. If, therefore, when at large, they depended principally upon winged insects for subsistence, their lives would indeed be laborious ones; but insects of sluggish movements, ants, and small spiders, are all freely partaken of. My friend Mr. George Pine, of Trenton, N. J., a very careful observer, assures me that of the two insects, house-flies and Croton-bugs, his lizards certainly preferred the latter, but were not particularly expert in capturing them. And now, assuming that the eye-sight of these little reptiles is not highly developed, what of the curious "pineal eye" which they possess? Prof. Macloskie has recently announced in "Science" that it "is so well developed . . . that it may probably seem to warn its owner of the advent of daylight. It is a lenticular, glassy area of the skin of the vertex (about a millimetre in sagittal diameter), surrounded by a yellow border, and having a dark spot in its center. The dark spot is opaque, caused by a mass of pigment internal to the

dermis, set on the extremity of a pineal outgrowth from the brain. The clear area around it is caused by the dermis, which is transparent and free from the pigment which covers it internally in other parts. The eye is covered by an escutcheon-shaped epidermal shield, more transparent in the center and larger (three by three millimetres) than the normal epidermal scales. The only sign of degeneracy is the central cloudy mass of pigment, like a big cataract."

I was naturally desirous of determining for myself how far it was sensitive to light, but found the investigation beset with difficulties. Chloroformed lizards that were deprived of their eyes, although the amputation was dexterously performed, did not revive sufficiently to make their subsequent movements suggestive; or did sympathetic ophthalmia set in and affect the pineal eye?

I subsequently hit upon a plan, using very thin India-rubber cloth, by which the eyes proper were effectually closed, and the "eye" of the vertex left free. The lizards thus provided with a blinding head-gear were separated from their fellows and placed in a roomy inclosure, made up of several almost dark and very light alternate sections, the temperature being even throughout the lizards' range. The arrangement was, perhaps, too artificial for a satisfactory series of observations, but it became evident at once that the lizards recognized the difference between the dark and light areas, and their prompt return to the latter when removed from them, and again their actions when they returned, all showed the appreciation of a difference, which I know was not one of temperature, but beyond this I could determine nothing; but I recalled, at this juncture, the significant fact that in the woods about May's Landing I noticed many lizards buried in the fine sand and leaf-mold, their eyes closed and covered, but the top of the head and a portion of the back, for its whole length, exposed. The same was subsequently noted as a position frequently assumed by the lizards in my Wardian cases. If, therefore, the "pineal eye" is sensitive to light, it is still of some use to the creature, as it would certainly respond to a passing shadow, and so warn the animal of the approach of a possible enemy. It certainly would be greatly to the lizard's advantage if it had a perfect eye in the top of its head, especially when it rests upon the trunks of trees, and is exposed to the attacks of predatory birds; but the "pineal eye" is at most but a remote approach to this. On the other hand, it was found that whenever I converged the rays of light with a burning-glass, always so suddenly that no thermal effect was produced, there was caused a movement of uneasiness, a flinching, on the part of the lizard that was extremely suggestive.

The most superficial examination of the external ear of the pine-tree lizard will at once lead one to infer that the animal's hearing is acute; and this is true. When watching the lizards on the trestle over Babcock's Creek, at May's Landing, I was forcibly struck with this fact. Such of them as were basking on the timbers of the bridge were not disturbed when I approached them with moderate care, stepping only on the cross-ties, or between them; but if I struck the rails with my cane they instantly took notice of it and assumed a listening attitude. I subsequently experimented upon this point, and found that when my companion struck the rails a smart blow, even at a distance of fifty yards, the lizards were aware of the peculiar sound, and acted accordingly, even darting out of sight with that swiftness that characterizes their first few steps. I have recently learned from Rev. John E. Peters, Sc. D., of May's Landing, that his observations lead him to conclude that the sense of hearing is not very acute, and that they depend principally upon that of sight for safety and the finding of their food; but his experiments were not so extended as my own, and limited too largely to specimens in confinement.

It is a most interesting fact, although so very wild when first met with, that, once captured, they instantly become tame. Indeed, I have had them lie quietly upon my hand, while walking in the woods, and make no effort to escape. There is a bare possibility that the efforts on their part to escape, and fear, when finally captured, may produce a hypnotic condition, or something like it, but this would pass by and leave them wild. This, I think, never occurs. Once in my hand, I have never known a pine-tree lizard to be otherwise than perfectly tame. But, in a large series in confinement, I found that the sense of hearing was constantly brought into play, as shown by their ludicrous actions when flies, shut in a thin paper box, were placed near them. They not only heard but recognized the noise—a very important matter, bearing as it does upon their intelligence. Indeed, in the woods about May's Landing I found that the lizards were perfectly familiar with many sudden sounds and paid no attention whatever to them. Some of these were the sonorous croak of the bull-frog, the quick scream of the blue-jay, the rattle of the golden-winged woodpecker, and the coarse cry of the great-crested fly-catcher. These were all unheeded, while my own coughing, the whistling of a single note, or the loud utterance of a word, caused them either to assume a make-ready attitude or to dart away. On the other hand, have these lizards any voice? Their actions *inter se* are strongly suggestive of the affirmative, but, so far as I am able to determine, their utterances are confined to hissing, and this I only heard when I provoked the creatures

by the sudden infliction of severe pain. Among a large number, in nine weeks I never heard a voluntary hiss. This, however, is wholly negative evidence, and I am disposed to believe that an animal possesses a voice, if its habits, in their entirety, suggest that it has one. This perhaps unscientific method of reasoning arises, on my part, from the fact of having long suspected that certain fishes and salamanders had voices, before they were detected—my suspicions being based upon the habits, as a whole, of these creatures. Certain snakes, too, that are now thought only to hiss, will, I believe, be found to have a limited range of scarcely audible utterances: so with the pine-tree lizards. I certainly have no reason to believe they talk, but possibly they may whisper in each other's ears.

Upon several occasions I sat, unseen by them, for a long time, very near my pen of lizards, and listened attentively, hoping to catch some sound that was clearly a voluntary utterance of a lizard. I only determined that one's ears, under such circumstances, become highly supersensitive, and a great deal is heard at a time when, in fact, positive silence prevails. Generally, the lizards were perfectly quiet, but at times one would move, and then a general scuffling ensued; but how far the noises were attributable to their activity I can not say; probably entirely so. The faint, snake-like hiss, that has fairly to be squeezed out of them, is the range of their vocal utterances, so far as I yet know.

Concerning the breeding habits of this creature, I had no positive knowledge prior to my visit to the pine-barren regions of southern New Jersey. I had heard the statement made that the eggs were small, quite numerous, and deposited on the under side of prostrate logs, and even in loose wood-piles that were constantly disturbed, and that the eggs were not concealed or protected in any way. All this I knew to be false; but where were the eggs of the pine-tree lizard placed? Questioning observing residents of localities where the species abounded, I was invariably informed that the eggs were laid in sand, in pits dug by the lizards and carefully covered up. They were only discovered by accident, no trace of their presence being noticeable. Further, that after heavy showers the eggs were sometimes exposed, and in this way a check was put upon the increase of the animal's numbers. Of course, solar heat alone was relied upon to mature the eggs. Recently, Rev. Dr. Peters has informed me that the eggs "are said to be laid in bunches," but just what is meant by being "bunched" I am at a loss to understand. They certainly are not attached to each other by any agglutinating substance. At least, the female lizards in my pens laid only dry, free eggs, which they deposited in conical pits, one egg, the lowermost, be-

ing in the bottom, then three above it, and four in the third tier. Such was the position in two sets of eggs, while the others were scattered over the sand in bewildering confusion. None of these hatched, the failure to do so, inasmuch as they were fertile, being due, I believe, to the surroundings being too dry. Probably a certain amount of decaying vegetable matter is mingled with the sand when the eggs are laid, and thus a moist heat is produced, which is as necessary as it is in the case of the eggs of the alligators and crocodiles.

The ova laid by my penned lizards were long, narrow, covered with a tough skin, free from calcareous matter, and varied in weight from twenty to twenty-four grains. At May's Landing, I am told, the eggs are usually laid about June 1st, and hatch about July 10th.

While the abandonment of their eggs in this apparently heartless manner leads to the supposition that they are indifferent to their offsprings' welfare, which is true, it is somewhat interesting to notice how very tolerant they are of the petty annoyances to which their own or another's young subject them. My observations on this point were made from a number of young and old confined in a roomy Wardian case, but probably what I there saw holds good among the lizards in their native haunts. I am sure it did among the many living on the old trestle at May's Landing. Often a little lizard, and sometimes two, would perch upon the head and back of an adult, and there be allowed to sit for fully an hour. The sharp claws of these youngsters seemed at times dangerously near the eyes and ears of the patient old one, but it offered no resistance, and, when I forced such burdened lizards to move, it was always with a deliberateness that suggested that they were really averse to disturbing those resting upon them. Again, adults would often rest upon each other, in what appeared to be a most uncomfortable manner for the one beneath, often pressing the head of the latter into the sand and completely blinding it for the time; yet I never saw the slightest evidence of ill-humor, not even when they were being fed. Often it happened that some sleepy fellow would quietly snap up the fly toward which another lizard was cautiously crawling, yet no fight ensued. Anything more trying than this to humanity can not be imagined, yet the lizards took every such occurrence as a matter of course.

In running, as well as when walking about deliberately, which they less often do, the lizard brings all four limbs equally into play, and their gait is much like that of a cat. When progress is suddenly arrested, they usually squat upon their hind-limbs only, holding their head well up and elevating the body, as does a cat or dog, by keeping the fore-limbs straight. Every attitude is suggestive of intelligence, and I refer particularly to the matter, be-

cause the differences in these respects between this lizard and the blue-tailed skink, the only other saurian found in New Jersey, is very marked; the latter, as we shall see, although having less suggestive manners, has, I believe, a greater degree of intelligence.

BLUE-TAILED SKINK (*Eumeces fasciatus*).

I have spoken of the rapid and complete submission of the pine-tree lizard when captured. While rowing from point to point along the rocky shores of Lake Hopatcong, Morris County, N. J., early in May, 1887, I chanced to see a beautiful "blue-tailed" skink, an old male that was now of a uniform rich brown color, and with a brilliantly red head. My one thought was to capture it—but how? I was in a profoundly cranky boat, and the water at this point was very deep. I tried a cold douche, and the bewildered skink, leaping into the lake, was caught as it clumsily swam toward shore. I placed it in a Wardian case, May 20th, and immediately it burrowed in the thick mat of sphagnum at the bottom, and for a week seldom if ever made its appearance. I could only determine that it was alive by searching for it, and invariably was bitten. It then showed a disposition to come from its inter-sphagnian retreat, but remained wholly suspicious of every sound or object that approached. Concealing myself, I watched it carefully, and found that the shutting of a door, the crowing of a cock near the window, and loud conversation in an adjoining room, always frightened it; while the singing of a canary, and of robins in a tree near by, were not noticed. A quickly passing shadow was particularly feared. Did it associate this with the birds of prey that are the skink's most dangerous enemies? Having disappeared, it never returned by the same burrow, but, cautiously peeping from a hole in an opposite corner of the case, studied the outlook for a long time before reappearing. It showed no disposition to be sociable until June 10th, when it seemed suddenly to gain confidence, but only to a slight degree. June 19th it ate for the first time, and then became somewhat tamer, but still was essentially wild, and seemed perhaps the more so because of the contrast with the pair of lizards that were all the while its companions. July 29th it was transferred to a roomy fernery belonging to a friend, where it found a close resemblance to its lake-side home in all essential features, and immediately it became more active; and now, nearly four months after capture, has become comparatively tame.

The skink, as we have seen, is exceedingly shy, irritable, and resents the slightest interference by biting savagely, but of course is entirely harmless. Nearly every prominent feature of the lizard

is represented by an opposite trait in the skink. What appeared to be evidence of more sluggish wits than the lizard possesses, is the fact that it did not learn to associate my presence with a supply of food, as was true of the others, but the truth is it was its greater fear of man that held it back, and not really a want of cunning.

In many respects the skink recalls the snakes, and its manner of crawling, often without making any use of the posterior limbs, and generally keeping the body greatly bent, adds to the resemblance; and so, despite its shyness and courage when captured, evidences of intellectual strength, the skink seems lower in the scale of intelligence than the pine-tree lizard, but they are probably their superiors; and both are telling examples of the law of evolution.

THE LAST STAGES IN THE GENEALOGY OF MAN.

By M. PAUL TOPINARD.

II.—*Concluded.*

WE have still another question to examine before taking up the relation between the Old World monkeys and man. We have determined an intrinsic ascending series in the American monkeys. Can we find a like one in the monkeys of the Eastern Continent?

Two stages of evolution are first determined—one which concerns the tailed or ordinary monkeys, and the other comprising the four tailless catarrhinian or anthropoid apes, among which also two degrees are recognized—one for the gorilla, chimpanzee, and orang, and the other for the gibbon, which is the manifest transition between these and the tailed apes, more particularly the semnopithecoids. To these four must be added two fossil anthropoids—the *Pliopithecus antiquus*, observed in 1837 by E. Lartet in the Miocene of Sansan, an animal probably allied to the gibbon, and the *Dryopithecus Fontani*, which was found by Fontan in the Miocene of Saint-Gaudens, and which is incontestably an anthropoid, but something other than existing anthropoids.

We may also present as proof of evolution in the group of monkeys the *Mesopithecus pentelici*, of which M. Gaudry has collected in the Miocene of Pikermi, in Greece, specimens belonging to twenty-five individuals. It does not fit into any of the existing genera, but is allied by its skull to the semnopithecus, and by its limbs to the macacus. We can then suppose that it is the ancestor of these two by a kind of doubling of the type, such as seems to have taken place in a considerable number of marsupial types.

M. Vogt involuntarily furnishes an argument in favor of this

interior evolution. There is a gradation in the arboreal life of monkeys. The American monkeys and the semnopithecoids do not leave their trees; the magots frequently come to the ground, and are only half tree-dwellers; while the macacus and cynocephalus are ground-dwellers. It is not allowable for us to believe, in view of their perfect adaptation to life on trees, that the magots, and, with stronger reason, the macacuses and cynocephaluses, correspond to an effort in a new direction—a direction by continuing in which we could conceive that they might eventually raise themselves again to an intermittent oblique attitude, and thus favor new adaptations.

Gratiolet, at a time when he could hardly dream of the doctrine of evolution, from which, moreover, his religious sentiments removed him, conceived the idea of parallel series among the monkeys of our continent, leading, for example, from the semnopithecus, peculiar to Southern Asia and the neighboring islands, to the gibbon and the orang in the same region; from the macacus and magot to the chimpanzee; and from the cynocephalus to the gorilla. Without suspecting it, Gratiolet was preparing for the doctrine of the derivation of man from the monkey, and was associating himself with the polygenist ideas then in favor in the anti-orthodox school.

This leads us to our last genealogical stage—the passage from the monkey to man. I begin by describing the principal opinions on the subject that have been in vogue or that may be sustained. In the theory of M. Haeckel, who is monogenist for man as he is monophyllitic for the other branches of his genealogical tree, the tailless monkeys of the Old Continent constitute the nineteenth stage from the monera. They are divided into four branches, the fourth of which is that of the anthropoids; and this is separated into African and Asiatic branches, the latter of which is divided in turn into three; the third of which gives the Pithecanthropus, or man-ape, which has already a vertical position, but is without speech. It is his twenty-first stage, the anthropopithecus of M. de Mortillet, from which living man, the twenty-second and last stage of M. Haeckel, is derived by two branches—one for the woolly-haired negroes, and the other for the straight-haired races, of which the Australian was the prototype. The place where man was thus originated by the acquisition of articulate language is fixed on M. Haeckel's map to the southwest of India, where the hypothetical lemurian continent may have been. The spot is marked Paradise, and is the point of departure whence men have scattered in every direction—some west to Africa, others east to Australasia and Melanesia, others north to Europe and Asia, and thence by Bering Strait to America.

Mr. Huxley does not express his opinion on the immediate descent of man in any of his writings that I have read. He leaves the reader to infer the consequences of the discussions into which he enters, and these lead to an origin at the expense of the anthropoids.

Prof. Gaudry is also very reserved, but lets his opinion appear, while he does not give it distinct form. In his scheme the series rises, marsupials, ungulates, lemurs, and catarrhinians forming a single group; anthropoids; and man. The anthropoid designated by him is the dryopithecus, of which he says: "The dryopithecus was a monkey of a very high character, and approached man in many particulars; it was of nearly the same size; in its dentition may be recognized characteristics of the teeth of the Australian" ("Fossiles primaires," p. 236). Further on he adds: "If, then, it should be shown that the flints of the Beauce chalk collected at Thenay by the Abbé Bourgeois have been cut, the most natural suggestion to my mind would be that they were cut by the dryopithecus" (page 241); "unfortunately, we possess of this dryopithecus only a lower jaw and a humerus."

Prof. Cope has an opinion, peculiar to him, that man is not descended from the monkeys, anthropoid or other, but directly from the lemurs. His condylarthra, the stock of nearly all the mammalian orders, give rise especially to a branch which is divided into three, one being represented chiefly by the genus *Anaptomorphus*, and separating in turn into two branches, one of which engenders the monkeys and anthropoids, and the other leads directly to man. His principal reasons for this view, which follow, show on how little our genealogies sometimes rest. Man has, as a general rule, four tubercles or cuspids in his upper molars. The monkeys and anthropoids have usually five tubercles. The recent lemurs, the fossil Necrolemur, and the Anaptomorphus, have generally three tubercles. Now we sometimes observe three tubercles in man. Prof. Cope has drawn up a long list of the degrees of frequency of this form among the races. The reversion is one that works toward the lemurs, and not toward the monkeys and anthropoids.

M. Vogt's present opinion is radically different; but the learned professor at Geneva having at different times had nearly opposite opinions, and having played a considerable part in the question, we shall dwell longer with him. His first view was expressed in 1862–'64, before Darwin had formally applied to man his doctrine of derivation by selection, and before M. Haeckel had in 1867–'68 for the first time fully explained his genealogical tree. His second opinion is known to me through his magnificent book on the mammalia, which appeared in France in 1883.

In his first view, the author having exhibited the resemblances

between the anthropomorphous apes and man, and defined the point from which the descent probably began, adds that it does not result that this descent follows a single way. There are secondary types among the human races, as there are among the monkeys. By prolonging the parallel series of Gratiolet we get the multiple stocks of man. "All the facts together, instead of indicating to us a common stock, a single intermediate form between the monkey and man, point to numerous parallel series which, more or less circumscribed, must have developed themselves from as many parallel series of apes" (p. 626).

The second opinion appears less clearly defined than the first. On the one side M. Vogt maintains his former ideas of polygenistic simian descent, and on the other he reverses them by formally denying that man is descended from the monkey. The monkeys, he assumes, have always, as they were in the Miocene and Pliocene epochs, been cantoned in tropical climates. Essentially tree-dwellers, they leap from branch to branch, and are hardly ever displaced—not even those ground-living monkeys that climb among the rocks. The separation between the monkeys of the Old and of the New Continents has always been complete, there having been no communication between the two hemispheres since the Eocene, or at least since the Miocene. Monkeys not going into cold countries, they were effectually prevented from approaching Bering Strait. They have, then, been but little modified, especially in the Old Continent, where they are more exclusively tree-dwelling. Higher types, like the laopithecus of America and the dryopithecus of Europe, are met among them after the Miocene, but they have undergone no further evolution since. The fact of M. Gaudry's mesopithecus is the only one that can be cited as in favor of any evolution.

But M. Vogt speaks here of a tendency toward a superior organization like that of man, of an approach by different ways, the gorilla resembling man more in its limbs, the orang in its brain, and the chimpanzee in its skull and teeth. "No fact," he says, "permits us to assume a single only line of evolution toward the human organization." Passing, then, more particularly to fossil species, M. Vogt insists upon his proposition that "there has been no evolution of the simian type through the geological ages," and that "we can not point to any advance of this type since the Upper Miocene."

I see nothing leading to this conclusion. As I have just shown, there are as many probabilities of an evolution among the apes as in any other zoölogical group. No series of species, it is true, leads positively from any ape to any man. But, in paleontology, what are exhibited to us as series of species are usually only series of characteristics. Comparative anthropology shows us a

great number of characteristics forming series, proceeding from the apes to man, and passing or not passing by the anthropoids. M. Vogt ends with an argument that has more weight: "The infantile ape is more like man than the adult ape, and their differences, characterized by the evolution of the jaws, the cranial crests, etc., become pronounced only with age"; and, finally, "the conclusion results from all these facts, that man can be placed in direct generic relation neither with recent apes nor with any of the known fossil apes, but that the two (man and the ape) have risen from a common stock, the characteristics of which are still visible in the age of youth, which is nearer to the stock than the adult being."

M. Vogt's last argument is *a priori* correct. Every one has remarked the contrast between the skulls of the young and the adult orang or gorilla. Its value rests on the admitted principle of the parallelism of ontogeny and phylogeny, which is expressed by saying that the forms of the young subject reproduce forms that have existed in ancestors, and thereby indicate their filiation. In other words, the new characteristic in progress, that which should connect a species with a succeeding species, exists in the adult in the highest degree, while the characteristic that belongs to the ancestors exists in the infant when it is wanting in the adult. As an example, we cite the pulmonary respiration of the adult salamander and the branchial respiration of the young salamander.

But it is necessary to distinguish what is produced after birth and is a fact of the growth of the body, of physiological development by the progress of age in the individual life, from what is an ancestral resemblance dependent on the embryological and intrauterine ontogeny. In the infant man, as in the young ape, the skull is rounded in every direction, uniform, and almost without asperities. The temporal crests and the sagittal crest, which is only the result of the elevation and lying back of the former on the median line, are developed on either hand with age, especially in the male, and are in relation with the strength of the muscles that are inserted upon them. They become considerable in the apes, and form large temporal bones in the species that have a considerable masticatory apparatus.

The superciliary arches grow in man and in the apes with age, and do not take so remarkable an aspect in the latter, in the anthropoids, for example, only because they have more ample frontal sinuses, which is a secondary characteristic. The projection of the jaws, also, becomes marked in both only with age; the human infant has an orthognathous, minute face, hidden under a skull forming a great ball, as in the orang; this face grows, lengthens, and becomes prognathous, partly by simple augmenta-

tion of volume while the skull becomes relatively diminished, partly because the molars of the second dentition need room and push the jaw forward.

I expect to describe hereafter how the relations between the base of the skull and the base of the face along the naso-basilar plane change, on either side, with the adult as compared with the infant, the angles which craniometry marks in that part. The facial angle, which I mention because it has a certain popularity, is larger in the young ape than in the infant man. The infantile forms of the young ape which M. Vogt speaks of are partly found in the adult woman. They also characterize the male sex of certain races, like the Andamans, which have for that reason been designated as infantine.

There is one characteristic implied in Prof. Vogt's argument which seems to bear more favorably to his thesis. It is that the young ape, the orang or chimpanzee, for example, is more intelligent than the adult. This, we might say, is because it is descended from a more intelligent ancestor than recent apes. But greater intelligence is a rule with all young animals, as well, if we take the circumstances into account, as with man. The brain is at that period larger in proportion to the body; it is in some sense virgin, more impressionable; it grows excessively, and asks only to absorb, to work, to turn the blood it receives to account. What is more marvelous than the way our children learn to talk, read, and write? Would we adults be capable of the amount of rapid memorizing which the mass of words and ideas inculcated into them at that age exacts? Young Australians are equal to Europeans in the schools, and retain languages with extraordinary facility; but, as age comes on, their savage nature reappears, they take off their clothes, they join their like again, and they manifest no more intelligence than if they had never been among the whites. If at our age we appear so capacious, intellectually speaking, it is because we have been accumulating for many years, because we reason in great part by habit, automatically; because we are incessantly excited by the struggle for existence, by the society of our likes, and by the use of language, which apes do not possess. M. Vogt's last argument, that the young ape is more human than the adult ape, does not, therefore, convince me.

I have mentioned the different opinions in view, positive and negative, concerning the origin of man. Are there not other possible ones? Although I have made many objections to M. Vogt's theory, his uncertainty, so remarkable on the part of a man who is usually not afraid to speak out, has made me reflect. I have asked what could this stock be which he speaks of, common to the ape and to man, and which is not lemuroid? While he leaves his readers still in suspense, it is easy to see his tendency. This

stock started from some point in the ungulates. I have manifested my repugnance to supposing such an origin, which appears monstrous. But while this repugnance is legitimate when we have regard to recent species—the extremities evolved from the branch—it is less so when we go back to the trunk before the specialization of the ungulates had become as pronounced as it is now. It must be said that nothing is impossible in nature; that things the least probable when we look at the outcome are realized by the most unforeseen processes, the most tortuous roads. What selection by the hand of man has done for pigeons is found done in nature by means the laws and mechanism of which are invisible to us, and which we can only denominate chance.

There is one objection to the descent of man from the ape which I have entertained, and which comes to the support of M. Vogt's thesis. As I have previously said, the primordial type of the mammalia has four limbs, the destination of which is already written out as far back as we can go; all four fitted to walking, but the fore-limbs adapted besides to serve as organs of prehension, while the hinder ones are essentially organs of support and walking. This double specialization goes back to the reptiles, not to speak of the dinosaurians, with which it is very marked. Some amphibians present traces of it. With the most ancient mammalia which are known in all their parts, like the *Phenacodus primævus* of the Lower Eocene of Wyoming Territory, the fore-limb is well characterized as an organ of prehension and the hinder one as for walking. The humerus is articulated with a narrow glenoid cavity at the upper outer angle of the omoplate, so as to permit the freest motions in different directions; the radius is mobile on the cubitus, around which it performs the turning movement required by the function of the hand; the five fingers are spread out, the thumb is turned more on its axis as if to permit opposition, and the hand continues in a straight line with the forearm. On the other hand, the femur is united, as with us, to a massive pelvis; the articular surfaces of the knee, the knee-pan, and the two immovable bones of the leg, are just what the exclusive function of locomotion requires; the foot is plantigrade, with a prominent heel and close toes, and is articulated perpendicularly by its arch with the leg, as in man. With another contemporary animal of the same bed, the *Coryphodon*, of which I have only representations of the foot and hand, but those whole, to judge by, these two organs present more resemblance, the foot being a little like a hand, but the differentiation is nevertheless made.

This specialization or differentiation has reached its maximum in man, no other animal showing it in equal degree. In the bird the upper limb has become a wing, that is, a function of locomo-

tion. With man alone the upper limb is exclusively a hand. The hinder limb condenses in itself all the locomotive function which it has till now shared within certain limits with the fore-limb, but which has nevertheless remained directly its essential attribute. Man thus seems to be the direct continuation of the first Eocene mammalia; if not of the marsupials that preceded them, the confirmation of a type that had been begun; and it does not appear very logical that his transformation should have been effected at the expense of a branch which appears collateral. The monkeys have been produced by an adaptation of the hinder limb to an arboreal life, the fore-limb remaining what it was; this is a deviation in some way from the axis of evolution, a deviation from the primitive type. From this primitive type have been detached on one side the ungulates through a metamorphosis of a fore-limb adapted to prehension into a limb adapted to running, and through a harmonic perfecting of the four limbs for the same purpose; on another side, the carnivores, whose four limbs have been set, together with the teeth, the jaw, and all the skull, into harmony with the necessities to which they were subjected and the mode of life and regimen they had adopted; and, on the third side, the monkeys, which, seeing the earth taken possession of by swift-footed herbivores and bloodthirsty carnivores, have taken refuge in the trees, or at least have flourished and maintained themselves there, and have consequently fitted their extremities to that special kind of life.

For men to be derived from monkeys through the disappearance of the accidental adaptation of the hind-limb to a function normally devolving on the fore-limb—that is, by returning toward their primitive arch-ancestral type—seems strange. But it is possible, for nature does not take the shortest roads. From the carnivores, terrestrial animals, have descended the pinnipeds, which by a reversionary adaptation have had their limbs atrophied, brought near the body in the shape of paddles, and made to perform the part of fins. But the most probable is generally the most simple. The hook which such an evolution of man or of one of his precursors would have made is useless. It seems more rational to conceive the perfect bipedal and two-handed type as descending from a type which we have already seen marked out in Eocene times, and constituting the fundamental original of the mammalia. We should then have to consider the simian branch as a collateral branch in which the evolution has not gone beyond what is exhibited in the recent and fossil anthropoids.

This hypothesis would solve some difficulties in anthropology that seem insurmountable. The lowest human races known to us are so near to the higher races in proportion to the distance that separates them from the monkeys, that we can consider the

different men as forming a relative homogen—a species, as M. de Quatrefages contends. The most ancient human race, that of Neanderthal, is in the same category. Its cranial capacity—that is, that which really characterizes man—is still considerable and higher than in the lowest existing human races. Between the lowest mean of the capacity of the skull of human races, which I put in round numbers at eleven hundred cubic centimetres, and the mean of the highest anthropoid species, which I estimate at five hundred and thirty cubic centimetres, the distance is prodigious when we compare it with such slight mean differences—taking account of the relation of brain-volume to that of the body—as have been determined between the succeeding species, genera, families, and orders of animals. The working of such a cerebral transformation as this calls for would require a length of time defying all our conceptions.

Pliocene man has probably been found in America. Miocene man is indisputable, although we have not yet been able to demonstrate the fact. Now, it is in the Miocene that the monkeys appear with their existing characteristics. Has man, then, been constituted since they appeared? Did the evolution choose an animal whose hind-limb was organized for a life in trees, was at once hand and foot, when there were beside it and already previously existing animals whose organization presented a part of the desired characteristics? There is little probability of it; and considering, I repeat, the number of species which would have been needed to reach the actual constitution of our brain, it seems probable that the preparatory steps are rather taken in the Eocene epoch at the expense of one of those condylarthra which had already the principal morphological characteristics of man except those relating to the brain, and which Mr. Cope has shown to be intermediate between the marsupials and most of the recent mammals. From this point could be made the differentiation corresponding with different modes of life, which has given on one side the ungulate and carnivorous branches and many others that disappeared without forming a stock, and on the other side the quadrumanous and human branches.

The human type—that is, the type that was destined to result in the astonishing brain-development that we know, and to which all the rest is only accessory—had then a stem of its own—a stem which was the most central continuation of the general primitive trunk of the mammalia. In the present order of science, the mammalian class, as a whole, is compared to a branching tree, having numerous principal limbs, each terminating in efflorescences higher in growth. These are our most specialized groups, the *Equidæ* and the ruminants among the ungulates, the lion and the dog among the carnivores, etc. In this new system the com-

parison to an upward-growing tree, the central axis of which put out lateral branches, would be more just, the central stalk of it continuing to rise like the Lombardy poplar, and giving at its apex man.

Gentlemen, we have reached the end of our year's task. I have explained at length the genealogy taught by M. Haeckel, and have examined step by step the systems that have been proposed to take its place. We have inquired whether the point of departure of the vertebrates has been from a soft-bodied worm, or from a crustacean possessing an exterior skeleton. We have concluded that our genealogy has passed by the ganoid fishes, to land in what paleontologists call the labyrinthodonts, and what I have sometimes designated as medium vertebrates. Thence the current has carried us, not in the direction of the mammals, which, however, had already appeared in the Triassic age, but into the full dominion of the reptiles, where we speculated concerning the dinosauric origin of the monotremata or of some similar group. There we met the aplacental marsupials, which we designated as confirmed pro-mammals, and showed that, with some reserves—of the cetaceans, for example—all the recent placental mammals, and consequently ourselves, have issued from them. Here the problem became complicated. To this point, except for the origin itself of the mammals, our origin appeared clear. The lemurs were already a cause of embarrassment. The uncertainties increase respecting the immediate descent of man, although we have at last freed ourselves from prejudices respecting it, and can discuss it coolly. Several opinions, each advanced by illustrious authorities, confront us; I have expounded them impartially, occasionally myself raising objections, as well as favorable arguments. I have not done, and now you may say that I have some secret preference—that you are convinced of it.

There are for me only two doctrines to be considered—one which derives man from the primary stock of the mammals in a direct line and without the intervention of orders, not from a mathematical point, but from that confused mass succeeding the marsupials, in which the differentiations are indecisive and tend toward the ungulates or toward man; and the other one, which accepts the branch or the order of the primates with all its consequences—the lemurs or prosimians at the base, then the monkeys or simians, and man all alone at the summit.

Does one of these ennoble us more than the other? Certainly. The one that regards us as the dominant and central branch of the mammalian tree, the continuation of the prototype in the direct line, and which posits us as the crown of an evolution, the point of departure of which is at the monera, is well calculated to

flatter our pride. But is it true, and would not our choice of it be a subjective one?

All that I have told you this year and last shows that I incline toward the other solution, and the conclusion that we are descended from the monkey. One consideration to me takes the lead of all the others. The type of the cerebral convolutions in all the primates where it is well characterized in its ascendant evolution is that of man; it varies from the cebian to the pithecoid, from that to the anthropoid, and from the last to man only in degree.* The development to the extreme of the simian type of the circumvolutions, and the abrupt increase in the volume of the brain in passing from the anthropoid to man, on which I have insisted, are, apart from the histological examination, the two fundamental anatomical characteristics of man.†

That the foot of the monkey has a more or less opposable thumb; that it is more or less adapted to their arboreal life; that it should appear strange to us that the human line, after having experienced a partial transformation of its foot, should have resumed the original foot of its ancestors—these are details. The cranial and facial characteristics, which are the result in man of the considerable volume of his brain, the atrophy of the nasal fosses, and of their numerous posterior cavities, which has brought about the disappearance of the muzzle, the compensatory perfection of the touch and the vision, which, with the modifications necessitated by the equilibrium of the skull, have contributed to a bipedal attitude and an entire new series of differential characteristics—are details also. That which dominates all is the cerebral type, already human, but in a rudimentary condition, in the apes, as it is the same type amplified and perfected in man.

All the organs—foot, hand, teeth, thorax, pelvis, and digestive tube—have been evolved in the mammals, have been transformed capriciously, have taken different courses, and have been specialized in different directions, sometimes to the same result. One only has remained stationary, or has varied but little—the brain—except in man. With him, or one of his ancestors among the primates, it took a start, it grew, developed, making everything bend to its needs, subordinating everything to its own life

* See P. Broca, "Anatomie comparée des circonvolutions cérébrales," "Revue d'Anthropologie," 1878, p. 385.

† According to M. Chudzinski, a competent authority on the subject, not only the type of the circumvolutions, but the muscular and visceral anomalies found in man, plead in an equal degree in favor of a simian descent. Some of the muscular anomalies even indicate reversion toward climbing or tree-living dispositions. See the memoirs of this anatomist in the "Revue d'Anthropologie," on "Muscular and Visceral Variations in Races," and in the bulletins of the *Société d'Anthropologie* on "An Anomaly observed in the Orang." See also his great work on the "Comparative Anatomy of the Circumvolutions," which was published in 1878, and reviewed in the "Revue d'Anthropologie," 1879, p. 707.

—the skull, the face, the whole body—and leaving its mark everywhere. Fishes swim, ruminants browse, carnivorous animals hunt their prey, the monkey lives in trees, man thinks. All in him gravitates around this characteristic. The philosopher has rightly said, "Man is an intelligence served by organs."

We are, then, descended from monkeys, or at least everything looks as if we were descended from them. But from what monkey, known or unknown? I do not know; assuredly none of the recent anthropoids has been our ancestor. From many monkeys or only one? I am ignorant of that also, and do not know whether I am a monogenist or a polygenist. In the study of the human races, I perceive arguments for and against both systems. I hope to reach their examination in a future course. Till then I ask for a reservation of opinion.

The subject we have been discussing is not done with; in fact, what I have said of my own opinion is premature. My earlier lectures next winter will bear on the comparative morphology of the skull, from the fish to man, especially among the mammals. Now that our descent from monkeys is contested by persons who are themselves partisans of our natural descent from the animals, it is of importance that we do not concentrate our exclusive attention on the primates. We shall see what arguments comparative craniology brings in favor of this or that genealogy or against it. We shall thus come upon atavistic traits which we shall then be in a situation to comprehend, upon rudimentary organs, upon analogies, and finally upon characteristics of the evolutionary order, or zoölogical ones, which I have divided in my programme into two categories—the retrogressive and the progressive characteristics. We shall thus complete the study of the cranial characteristics dependent on the brain, with which I began, and shall be able to pass to the characteristics derived from the skeleton, among which we shall again find the application of all the preceding evolutionary data. Then only shall we be permitted to conclude upon the place which anthropology makes for man in nature. Whatever may be the result we reach, this place, you may believe, will be as enviable as you could desire it to be.

I have said, in anticipation, that man is descended from the monkey; yes, but by a multitude of intermediaries more or less anthropopithecoid, of which paleontology possesses no remains as yet, but which the mind foresees, the first one having a brain like that of Vogt's microcephalus, its followers larger brains, with more circumvolutions, larger frontal lobes, down to the existing type. Originally, at about the beginning of the Miocene, perhaps, man and monkey made but one. A separation was produced, the gap enlarged, became a crevasse, then a gulf with steeper and steeper walls like the Colorado cañons—a gulf which our friend

Abel Hovelacque is not in favor of, but which MM. Vogt and Huxley, who are little suspected of orthodoxy, admit—a gulf which is growing wider every day under our very eyes; in which we are still permitted to perceive those lost paths, going from one side to the other, of which Mr. Huxley speaks in the preface to the French translation of his "Man's Place in Nature"; but which will soon become insuperable by the disappearance, on the one side, of the last existing anthropoids, and, on the other side, of the last inferior human races; when man will be left isolated and majestic, proudly proclaiming himself the king of creation.

We need not blush, then, for our ancestors: we were monkeys, as before them we were reptiles, fishes, yes, even worms or crustaceans. But that was a long time ago, and we have grown up. Evolution, let us say it, has lavished its favors upon us, and has given us all the advantages in the struggle for existence. Our rivals of yesterday are at our mercy; we leave those which displease us to perish, we create new species when we want them. On our planet we reign, fashioning things at our will, piercing isthmuses, going down into seas, ransacking the air, suppressing distances, and snatching from the earth its secrets of ages. Our aspirations, our thought, our action, have no bounds. Everything pivots around us. What more can we desire? To be god? That may come. Evolution has not had its last word. The anthropopithecus has been; the anthropotheomorphus may be. M. Hovelacque has tried to reconstitute the one; why may we not some day try to constitute the other, the man of the future?

ATOMIC WORLDS AND THEIR MOTIONS.

By Dr. HEINRICH HENSOLDT.

THIS formidable title will doubtless lead many of my readers to apprehend that I am now going to inflict upon them one of those abstruse and profound disquisitions on molecular physics which are very learned and very incomprehensible. But I do not propose to do anything of the kind. I have no desire to go into mathematics, or to weary them with a more or less tedious recapitulation of the gradual development, from crude beginnings, of our present science of molecular dynamics, by going back to the earliest conceptions of atoms by the Greek philosophers, or even to the time of Dalton and Bernouilli.

I merely desire to explain, in as popular a language as the subject permits, in how far the researches of men like Helmholtz and Sir William Thomson have modified our ideas of the ultimate composition of matter. There will be nothing offered that is

absolutely original except certain deductions of my own which, in my opinion, necessarily flow from the assumption that matter is composed of indivisible and indestructible particles. I have reason to believe that these deductions will be received with interest and that they will throw light on and explain many things which may have puzzled those not intimately acquainted with the subject.

It may, indeed, be presumed that a popular exposition of the present state of the science of molecular physics will be appreciated. Everybody has heard of and knows something about the atomic hypothesis, yet there are few who have been able to follow the more recent researches and speculations of the foremost inquirers in this difficult department, because they have been communicated to the world in a manner in which they can only be understood by mathematicians of the highest order. Such master-minds are necessary, and it was perhaps fortunate for mankind that they have hitherto confined themselves more or less exclusively to original research, and not frittered away their time by writing popular works; but it is the duty of humbler intellects to interpret their revelations, and give them the widest possible dissemination.

There is, in my opinion, no subject, outside of mathematics, however intricate or abstruse in some of its aspects, which can not be explained in the ordinary language of the people. What can be clearly imagined can also be clearly expressed; or we might as well carry science and philosophy back to the time of Duns Scotus, when it was considered the greatest triumph of learning to sophisticate so profoundly, and hedge around with arguments an obvious absurdity that no ordinary intellect could refute it.

I would also like to observe that in the manner in which I shall here endeavor to place this subject before my readers I have been largely influenced by the perusal of a recent work on molecular dynamics by Lasswitz, a German physicist and philosopher, little known as yet in this country, a profound thinker. To this work, which can not fail to make a great impression on all cultured minds, I am indebted for many of the similes which I intend to make use of. Some of these similes may appear fanciful or extravagant, but a little reflection will show their fitness and value in the interpretation of some of the more difficult problems with which we are here confronted.

Let us imagine ourselves, on a cold and clear winter night, suddenly transferred from this greatest and noisiest of American cities, hundreds of miles away, into the stillness of the country, or into the depth of some solitary forest.

Nothing around us seems to stir; we are far from the roar of cities; above us the silence of the stars, beneath us a soft carpet

of snow; not a sound to be heard, not a breath of wind stirring the branches.

And yet we know that all this is an illusion! Those bright points of light on the dark firmament are solar systems, whirling through space two hundred times faster than a cannon-ball, and under our feet the delicate snow-crystals are groups of atoms, which tremble with billions of vibrations every second.

The outer forms of the little snow-stars appear to us fixed and rigid like those of the bright constellations above. But from their surfaces a pale light enters our eyes, acts on the retina, and excites the optic nerve—an infallible proof that there is something active even in these—and we know of only one kind of activity in this universe, namely, that of motion.

The particles of which the snow-crystals are composed are not closely joined or cemented to each other like the stones in a wall. They are perpetually acting and reacting on the bodies which surround them, through the medium of an exceedingly fine substance which we term world-ether. It is the bearer of the movements, the effects or modifications of which we know as light, heat, electricity, chemical affinity, etc.; it also keeps the particles of the snow-crystals separate, maintains them in a state of mutual equilibrium, and regulates their vibrations. These vibrations we term the "mechanical cause of heat," because we are aware that every increase of temperature is represented by an increase in the rapidity of the vibrations.

These minute particles, of which, as we know, all bodies consist, are called molecules. In solids, as, for instance, the snow-crystals, they are arranged in a certain fixed order, and their vibration is limited to a given space. Now, let the sun shine on the snow.

The sun is a vast center of activity. From every point of its surface an enormous number of impulses are continually acting on the atoms of the surrounding ether, which are sent through space in every direction, with lightning-like rapidity. The number of these impulses has been estimated at from four to eight hundred billions per second. They give rise to a wave-like motion which traverses about two hundred thousand miles of space per second, and requires eight minutes to reach our earth.

If these ether-waves happen to come into contact with our optic nerve, we experience the sensation of light; if they impinge upon our skin, we feel warmth; if they strike the snow, they set its molecules, as well as the ether between them, into a livelier state of motion. The vibration of the molecules increases in violence, and the result is an increase in temperature in the snow. The particles have to move further away from each other, as their vibrations require more space—we say the heat expands the

bodies. At length the vibrations become so energetic that the fixed order in which the particles are arranged can no longer be maintained. They begin to collide and interfere with each other; the whole artificial edifice of the crystal collapses. The molecules can not regain their equilibrium—the snow has changed into water.

In liquids the molecules move about in all directions, yet none of them can voluntarily separate itself from the main body. Just as in a vessel, completely filled with live eels, each individual fish may wriggle and move about among the others, yet it can not detach itself or swim away from them. The liquid particles are not yet sufficiently potent or energetic to overcome the pressure exerted upon them by their surroundings. Above the water, even in the open vessel, they have to encounter the pressure of the atmosphere, the molecules of which keep up a constant and vigorous bombardment against the liquid particles, forcing them down. Still, this can not prevent that here and there a favorably situated water-molecule pushes itself between the air-molecules; the water evaporates. Now, if the temperature is heightened—that is, if the vibrations of the water-molecules increase to such an extent that they can hold their own against the pressure of the air—then a condition of things is brought about familiar to us under the name of *boiling*. The water-particles shoot about very rapidly; they are no longer crowded together, they force their way through the air-molecules and disperse—the water *evaporates;* we have no longer liquid but gaseous water.

In gases—as, for instance, the air, carbonic acid, etc.—the molecules are in a state of vibration so violent that they fly about with marvelous rapidity in all directions.

Now, we are in possession of information—of pretty accurate information—respecting these molecule-movements. The researches of men like the late Prof. Kingdon Clifford, Prof. Helmholtz, and, above all, Sir William Thomson—one of the ablest physicists and beyond comparison the greatest living mathematician as well as one of the subtlest thinkers the world has ever produced—the researches of men like these have thrown quite a flood of light on this important and highly interesting subject. Nor is our information merely confined to molecular movements and vibrations; the dimensions of the molecules themselves have been approximately ascertained, because, from known facts of pressure, friction, and heat-conducting capacity, very reliable conclusions can and have been drawn.

The air which surrounds us is a chaos of innumerable minute solid bodies, flying rapidly about in all directions. Our skin is perpetually bombarded by them, and it is this bombardment which causes us to experience atmospheric resistance or press-

ure. These air-molecules, if closely packed (without any intervening space), would only fill about $\frac{1}{3000}$ of the space taken up by the air as it is. They rush about in this void with the quickness of rifle-bullets. Every point of our skin is struck by at least five thousand millions of these little bullets every second. Their number is so great that every cubic inch of air contains no less than twenty-one *trillions* of them, and the same is true of all gases. They are so small that they are utterly beyond our powers of perception.

The smallest object which the best and most powerful combination of lenses, as now produced, would still enable us to recognize, requires a diameter of at least $\frac{1}{100000}$ of an inch, but of oxygen-molecules three hundred could be placed side by side before they would cover that minute distance. Still smaller are the molecules of hydrogen.

Now, in order to get a clear idea of this air which we inhale, of this hail-storm of little worlds which we perpetually encounter without apparent discomfort, let us resort to a little arithmetic and imagination—not the imagination of the poet and romancer, which delights in pictures of the fanciful and ideal, without taking much account of facts, but the healthy imagination of the scientist, which moves among the sternest of all realities, and which, if rightly exercised, becomes a potent factor in the elucidation of truth.

In this glass of water I observe a little air-bubble. It has a diameter of perhaps one thirtieth of an inch. Let us magnify this tiny bubble ten million times; let us imagine it ten million times larger than it is now, but first let us retire to a safe distance; for, the moment we touch it with our magic wand, it becomes a globe eight miles in diameter. In this globe fifty thousand billion little bullets, of the size of No. 6 shot, are flying about in all directions with the quickness of rifle-balls. Whenever one of these molecules, these shot-grains, comes in contact with another (and this happens about eighty million times every second), it is deflected from its course and takes another direction, but without the slightest loss of its original speed.

It may be asked, How can we manage to exist amid such a torrent of projectiles? we ought to be instantly annihilated. But we have forgotten to apply the same magnification-scale to our own persons. Let us do so, and we become giants seven thousand geographical miles in height. One of our feet would more than cover the distance from Chicago to New York, and with the other we could conveniently step across the Atlantic to Europe. Let the whole atmosphere be magnified in the same proportion, and it will be understood why the hail of little bullets perpetually bombarding our skin would not inconvenience us, for that skin would

have a thickness of from six to eight miles. The bombardment would produce no other sensation than we now experience when a gentle breath of air fans our cheeks.

The picture which I have here presented is by no means the product of a mere fantastic flight of imagination, but a conclusion strictly warranted by mathematical facts, and necessary for the interpretation of the physical phenomena of nature.

But chemistry has to go yet one step further, in order to explain and render intelligible the phenomena of combination and affinity. We are driven to the conclusion that molecules are not the ultimate particles of matter, but are built up of still smaller bodies, the *atoms*. Thus, for instance, in a molecule of water we have two atoms of hydrogen united to one of oxygen, and all chemical processes have their source in the fact that the atoms of two or more molecules of different substances detach themselves and reunite again in a different fashion.

Now, in order to obtain a better idea of the manner in which the atoms are grouped in a molecule, we must look upon the latter as a *cluster*, the various parts of which are combined by a well-regulated movement into a harmonious system. We may well resort, for comparison, to a process within our observation, though on a far grander scale, which is admirably adapted for illustration. Let us look to our planetary system.

The planets, with the sun, represent a stable system, just as the atoms of a molecule represent such a one. In the case of our solar system, the mass of the planets, compared with that of the central body, is, of course, very insignificant. A far closer resemblance to our molecules is therefore presented by those systems of the stellar world in which two or more large bodies, of nearly the same size, revolve around their common center of gravity.

This parallel between atoms and planets, molecules and solar systems, opens before us a new and startling perspective. It affords us a glance into that unfathomable abyss which hides the mysteries of time and space, and holds in its dark recesses the very secrets of existence.

Astronomical science has shown that our sun, with the majority of the fixed stars visible to us, constitutes a great star-cluster, the diameter of which must be estimated by hundreds, if not thousands, of billions of miles. Of such star-clusters there exist a great many, which, in their turn again, form a still grander system, to which we also belong, and the boundaries of which are indicated by the outermost limits of the milky way.

How *many* of such galaxies may be hidden in the vastnesses beyond, in the bosom of infinite space, we will never know, for the light can only reach us from limited distances. Whatever may be *beyond* that very farthest nebula, the pale light of which

has taken fifteen thousand years to reach us, is concealed from us forever.

But, as here in an outward and ever-enlarging scale, so in the molecules and atoms downward, and ever diminishing in size, we find system after system inclosed one in the other, like the ivory balls in a Chinese puzzle, downward, ever downward, *and there is no end!* We shall never be able to exhaust the possibilities of minuteness. The atoms of elements may consist of ether-atoms; indeed, the very elements themselves may not be elements in the true sense at all, but compound bodies, as has, indeed, been very long suspected.

Now, let us once more take our magic wand; let us imagine one of these tiny atoms enlarged to the size of this globe, of this earth, on which we live. A magnification of one trillion diameters would more than suffice. It would now, with its companion-atoms, represent a planetary system, and the molecules in a gas would stand in about the same relationship to each other as the fixed stars over us, which pursue their unknown courses; the little air-bubble in the glass of water becomes a star-cluster like the one in which our sun is situated. The circle of little bubbles around the margin of this glass would represent such a gathering of star-clusters as we now see before us in the milky way.

The galaxy in a glass of water! On what does the glass rest in which *our* starry firmament has gathered? Who will take it to his lips? We know not; we can not see beyond our tiny bubble, and the mere fact of being able to understand that we never *can* hope to look beyond it presupposes a great deal of understanding.

It will be worth our while to have a look around on our enlarged atom. We live on this planet of ours, but what entitles us to draw a line or fix a limit as to the possible or impossible in this endless, this infinite series of worlds with which we are here confronted? If we could descend on to one of these atoms, our bodies diminished in proportion, might we not, *would* we not, find there another earth grouped with its companion-atoms into a stellar system of perhaps wondrous regularity? That world in which a conscious being exists is determined by the *kind* of this consciousness, and by the character of the impressions which it is capable of receiving. We can not well think of perceptions other than our own, because we can not go beyond the limit of our own selves, but we can well imagine a world in which sensations like ours may succeed each other in far greater rapidity.

We can imagine a creature which in one second, during which we only receive at the utmost ten different impressions, is organized to receive thousands, millions, or billions. That means that in one thousandth, one millionth, or one billionth of the time *we*

live, it experiences the same number of things as we do from the cradle to the grave. Its measure of time, compared with ours, would be infinitely smaller.

Such a being could live on an atom just as conveniently as we live on this planet of ours. If, for instance, the quickness of its sensations were to ours as one thousand trillions is to one, it would experience in the time of one light-vibration—that is, in one five hundred billionth of a second—as much as we in eight months. The atom on which it lived would be its world; the molecule to which the latter belonged, its solar system; and by the revolution of atoms it could count its days and years. Above him, our atom-citizen would see other similar and far-distant worlds; for, the molecules, perhaps all belonging to one tiny air-bubble, would form the star-cluster of his firmament.

A magnification of ten thousand trillion diameters would enlarge the little air-bubble to the dimensions of our entire stellar system, the star-cluster of which the limits are the outermost regions of the milky way. But, great as the host of our stars may appear to us, the firmament of our atom-inhabitant would be still more densely crowded; for while we, with the aid of our best telescopes, can not see more than about twenty million stars, the little air-bubble would harbor at least fifty thousand billions.

Now, you might object that, to an atom-inhabitant, the molecules of a gas could not possibly appear as the fixed stars do to us, inasmuch as these molecules experience, on an average, about eighty million collisions in every second. However, it must not be forgotten that we have reduced the time of life and observation of our atom-inhabitant to one thousand trillionth that of our own. During this brief moment the relative positions of the visible molecules—to him far-distant suns—will appear just as unaltered, and their courses or orbits to the atom-astronomers just as linear, as those of our fixed stars appear to us.

What is the short space of time, the trifling moment, that we know of the life-history of the earth, compared with the eternities which must elapse before two fixed stars approach sufficiently close to render a collision inevitable? Our records of human history read back only a few thousand years, and of the age of our planet we only know that it must be measured by thousands of centuries. Of the courses of the fixed stars we know absolutely nothing; we only infer from certain data that their average velocity is about a hundred times greater than that of our molecules.

Thus the atom-inhabitants are about as wise as we are. The life of the entire human race, so far as our historical records are concerned, would, if condensed to one thousand trillionth, occupy about the one thousand millionth part of a second—less than one twentieth of the time which elapses, on an average, before the col-

lision of two gas-molecules—time enough for thousands and tens of thousands of generations of living beings to rise, flourish, and decay, before a perceptible alteration of their starry firmament can be recorded.

It remains to fancy to picture further how those atom-inhabitants imagine their world as the only world civilized and blessed by divine ordaining, for they know as little of other worlds as we do. Millions of their years may pass—by thousands the rise and fall of their nations, the dynasties of their rulers, the triumphs of their philosophers and poets may be recorded—before the water-glass with the little air-bubble, in which their planet is merely the tiniest atom, is seized by human hands, and billions of worlds are drawn in by human lips.

What an endless vista of life is here presented to us! Not enough that the vast space which surrounds us is peopled by innumerable worlds like ours, but *within* the latter *new* worlds are presented in the atoms, which in their turn again may harbor others still smaller, and so on in infinite succession.

And now the same step upward! Let us regard our *earth* as an atom, our solar system as a molecule. Of what larger body may it, with all the galaxies and star-clusters, constitute a particle? What a giant-world may *that* be, what creatures may inhabit it? *Our* universe, encircled by its galaxy of myriad suns, is it but a stray bubble floating on some mighty ocean of that greater world? This stellar system of ours, does it perhaps, in that giant-world, represent a molecule in some complicated organic structure—a nerve-cell in a giant organism, perhaps a brain-particle in the head of a Titan, whose feet rest on ground in the abysmal distances of space?

That Titan would have a height, if his body were proportional to ours, equal to a billion Sirius-distances! What thoughts, what sensations may move him, when, in his brain-cells, our suns clash in stupendous conflict and meet their doom in universal conflagration! And those Titans, whose bodies, whose *terra firma* is composed of veritable oceans of star-clusters, what a starry world may *they* behold above them! On the atoms now vibrating in our *own* brains, in the blood coursing through our veins, the destinies of nations may be fulfilled, destinies on the planets, which again are but the atoms of a higher world, destinies on the giant-worlds, and none of the beings is aware of the existence of the others; each has the solid ground beneath him, and above him the silence of the stars.

Therefore, if this thought should make us feel uneasy—the thought that this cherished world of ours is but an atom in a giant-world—let us take consolation in this: the giants are in no way better situated than we are in reference to the dwarfs which

inhabit the world of atoms. Stars above them, the ground beneath them, that is *their* world as it is ours. That *we* just happen to exist on the earth is a matter of comparative indifference. No matter *where* we might be, our astronomers would always investigate the starry firmament, our chemists and physicists would divide bodies into molecules and atoms. Everywhere the suns as the atoms would pursue their courses in obedience to the same laws, everywhere two sides in the triangle would be greater than the third, and everywhere twice two seconds would make four. That is the law for the giants and the dwarfs, the law beyond which we shall never be able to rise.

EVOLVING THE CAMEL.

By GRANT ALLEN.

AS I sauntered to-day down the Rue d'Isly, on evolutionary thoughts intent, I met a caravan of camels, in long single file, coming in from the desert with their bales of merchandise. Poor, weary creatures they looked, in all conscience, their humps shrunken to mere bags of loose skin, and their patient faces bearing all too openly the marks of their long and toilsome journey across the hill country. At their head stalked a lordly Arab in a dirty white burnous; drivers and attendants of lesser station followed in the rear with a tread as stately and solemn as the camels' own. For, dejected and foot-sore though they all were, men and beasts had alike even so the free and firm step of the open desert. Little Moorish children from the dark shops ensconced in the wall ran out with childish delight and clapping of hands to see them pass; women with their faces muffled up to the eyes turned timidly to give them a casual glance; and even old Hamid Abd-er-Rahman himself, sitting cross-legged on his bench before his cup of coffee in the open bazaar, deigned to remove his pipe from his mouth one moment and remark to Omar on the divan beside him that prime dates were coming in from the oases very well this season.

As for me, standing there in my alien garb, I rejoiced in soul that I had seen a caravan, and could forthwith begin philosophizing on camels. "I could have played on any timbrel," says the poet at the Zoo, "For joy that I had seen a whimbrel." And I could have burst prosaic trammels, for joy that I had seen those camels. Everybody knows, of course, the famous story of the German student who evolved the camel from his own inner consciousness. Now, that mode of evolving a species I hold to be illegitimate; you should always draw your animal from the life,

even though, like the Frenchman in the same old apologue, you only go to the Jardin des Plantes for the model on which you base your rhapsodical portrait. But when a man has actually been to Africa itself, and seen a caravan in all its glory, headed by a real live Arab in a burnous of the dirtiest, fresh from the sands and siroccos of the desert—who, I should like to know, if not he, is entitled to speak with authority about camels? For here I am, on the borders of the desert, upon whose flats I can look down (at a safe distance) from yonder mountain-heights; and if ever there was a case of "adaptation to the environment," the camel has indeed adapted himself wholly and solely to the conditions of Sahara.

Deserts, in fact, are exacting in the matter of adaptation; you must obey them or die. No other environment (not even perhaps the arctic snows) demands so much in the way of adaptiveness from all that live in it. The plants are every one of them saline and alkaline; they must content themselves with sand instead of soil, and with brackish pools instead of fresh water. The animals are all peculiar to their habitat; bird and insect must assume alike the uniform gray sabelline tint of external nature everywhere around them. Only two higher types subsist at all among those great sand-wastes—two types specially fitted for their own exceptional mode of life, one plant and one animal—the date-palm and the camel. They make Sahara. Nobody ever saw a picture of the desert without a date-palm and a camel in the foreground. Those two inseparable elements of the Africa of our fancy shall not be parted even in this sober biological sketch. Nature, indeed, has joined them together, and science shall not be permitted here to put them asunder.

And yet, though the camel as we know him is peculiarly Saharan, a product of the great African, Indian, and Bactrian deserts, it is not to the Old World that we must look at all if we wish to evolve the camel historically, rather than to develop him by *a priori* process from the depths of our own inner consciousness. It is America that gives us geologically the earliest evidence of the camel's ancestors; and it is America that still contains the greater number of species of the camel family, in the persons of the llama, the alpaca, the guanaco, and their allies. Prof. Cope has drawn up the pedigree of the race for us in full detail. The Asiatic and African camels, in fact, are mere surviving Oriental members of a family American in origin and history, but stranded, as it were, in a remote corner of the Old World, where they have survived the competition of newer and higher types in virtue of their special minor adaptations to the peculiar circumstances of their strange habitat. Having early fitted themselves in certain outer points to desert conditions, they have been enabled to outlive all their

younger and more highly developed competitors solely in virtue of their singular combination of desert-resisting qualities.

Now, it must at once strike everybody as a curious circumstance in the geography of animals that the existing cameloids should be so strangely distributed—one group of them in the desert region of Asia and Africa, the other group away across the world among the snowy slopes of the Andes of South America. What can be the meaning of so quaint a freak of distribution? Why should the two surviving cameloid tribes be thus separated from one another by half the earth's surface, and by many deep seas and shadowy mountains—one in the Old World and one in the New; one in the desert and one in the uplands; one in the northern hemisphere and one in the southern? Clearly, the answer suggested alike by geological facts and by analogies elsewhere, is simply this: we have here, as it were, two little surviving biological islands, colonies of an ancient race which once covered both worlds alike with its numerous members. Time was when the camels or their allies were of cosmopolitan distribution. They ranged, no doubt, the Eocene plains of all the great continents. But they are an ancient and in many respects an undeveloped ungulate form, which has become extinct elsewhere in the intermediate regions through the fierce competition of the higher ruminants, and has lingered on only under special circumstances in two remote corners of the world—in the deserts of Arabia and in the Andes of Peru.

The llamas and alpacas, as the lower and less specialized type of the two, explain best the true systematic position of the family. For South America, as everybody knows, is in many respects a very antique biological province. Less ancient in its life-forms than Australia, that world of living mesozoic fossils, it yet retains in many places the scattered remnants of its extremely old-fashioned fauna. There is reason to believe, indeed, that the circumpolar continent—Europe, Asia, and North America—was once for many ages continuous, while Australia, South Africa, and the South American peninsula formed separate islands in a wide and winding southern sea. Hence the higher life-forms developed rapidly in the broad and varied northern land-mass, while more antiquated types continued to live on, uninfluenced by their competition, in the three isolated southern provinces. Of these three, Australia alone still remains a great island; but South Africa has been joined to the Mediterranean world by a gradual upheaval of the Saharan area; while the Isthmus of Panama, still later in date, apparently, has formed a great natural bridge by which some of the North American land-animals have been able to invade the comparatively unpeopled tropical realms of the low southern species. In both cases, however, many of the low local

types still hold out in extreme recesses or under special climatic and geographical conditions; and thus the llama and alpaca have been preserved to our time intact in the narrow belt of temperate slope between the snow-clad Andes and the Pacific shore.

I have said that the cameloids are a very ancient type of ruminants indeed: their skeleton abundantly proves this fact; but I will not dwell at length upon such dry points of anatomical detail, because I fancy I have noticed on various occasions that the general public does not wildly interest itself in questions of carpal and metatarsal bones. It is not frantically enthusiastic about distinctions of odd-toed or even-toed ungulates. What most of us really want to know, and what the comparative anatomists as a body still studiously neglect to tell us in plain language, is how each animal came to obtain, not its bones which we don't see, but its distinctive external shape and characteristics—its horns, its tusks, its hump, or its antlers. We would rather learn a few simple facts about the evolution of the elephant's trunk or the peacock's tail than a whole volume of learned memoirs on the cervical vertebræ and the carinate sternum. Those things are doubtless very convincing in their own way, but they are not of a sort to rouse our profound personal attention. There are, however, two other visible points about the camel-kind which clearly mark their true position as very early ruminants indeed, and which can yet be readily apprehended by the ordinary surface-loving, non-anatomical intelligence. One is, that the camels as a group antedate the development of horns or antlers; the other is that they still possess in full, like other animals, those canine and incisor teeth which are partly obsolete, partly altered in shape, in all the higher and later ruminants. Each of these peculiarities has a meaning of its own, and points back to certain interesting episodes in the development of the great ruminant order.

The vast mass of ruminants generally at the present day possess some form or other of horns or their equivalents. In the giraffe, which in a few points (mostly delusive) approaches the camels, the horns are merely blunt protuberances of bone, persistent through life, and covered with a continuous hairy skin. They show us the lowest surviving stage in the evolution of frontal weapons. In the deer tribe, they appear at first under much the same form, as little knobs or bosses of bone on the forehead, underlying a fold of skin technically known as the velvet; but when the horns are fully grown, the velvet is rubbed off, and the bone alone shows its naked material as the branching antlers with which we are all so familiar in the Scotch red deer. Horns of this type are shed annually, and reproduced in more and more complex forms (representing successive ancestral stages) with each renewal. Finally, in the great central group of the

ruminants, represented in our day by the oxen, sheep, goats, and antelopes, the bony core or heart of the horn is protected by a sheath of agglutinated hair, which continues to increase by layers during life. This last form of horn is never shed, but persists through the whole of the animal's existence.

Historically, we know that the earliest ruminants, whose remains are preserved for us in Tertiary strata, were quite hornless; and the gradual evolution of horns and antlers, from the simplest to the most complex, has been traced out in full through successive geological ages by Gaudry, Boyd Dawkins, and other biologists. We can follow in detail the origin and rise of each tine and spike from the mere boss or knob on the forehead of the ancestral form to the branching horns of the reindeer, the wapiti, and the Irish elk. The camel, therefore, in its lack of horns represents for us an early undeveloped stage of the ruminant type, when the ruminants had as yet only just diverged from the common ancestors of the horses and pigs. Darwin has shown that horns and other familiar offensive weapons (especially when peculiar to the males alone, as is the case with the antlers of stags) have been developed in the struggle for mates, and are a necessary result of sexual selection. But all such ornaments belong to the higher and later stages of animal life, and are wholly wanting in the unarmed, undecorated, ugly camel. He is, in fact, a ruminant on which the higher types of selection have been little exercised, though, as we shall presently see, his special adaptations for a desert-life have been carried very far in particular directions, and so have enabled him to hold out bravely in his own narrow and restricted field against all more advanced and more highly specialized animals.

The teeth of the camels and of their allies the llamas tell the same tale in a somewhat different fashion. In all the higher ruminants—giraffes, deer, oxen, antelopes, and goats alike—the weapons of offense are the horns or antlers, and the teeth have almost or entirely ceased to be used in fighting. They have also undergone certain profound modifications of shape and arrangement (interesting only to the technical anatomists), which fit them for cropping grass or other low herbage, but get rid to a great extent of their tearing powers. On the other hand, there is one other group of ruminants besides the camels which is destitute of horns —the little group of musk-deer—and in these pretty, small creatures the canine teeth have been developed into long protruding tusks, which thus take the place of horns as offensive weapons, and are used by the males in their single combats for the possession of their mates. But, in the camels and llamas, no special fighting-weapon of any sort exists. When camels fight at all—which is very rarely—they fight merely by simple biting. They

remain in this respect on the lowest mammalian level. Their teeth approximate rather to the type which occurs in horses and some other outlying ungulate groups than to the type which occurs in the true ruminants. They have always canines in both jaws; but these canines are not lengthened out into regular tusks, nor do they serve to any noticeable extent as weapons of warfare. In short, the camels by many points of their structure point back to a time when the ancestors of the ruminants had not diverged at all widely from the ancestors of the horse, the pig, or the hippopotamus, and they still retain in many particulars the early "generalized," or rather unspecialized, type of the common progenitor of the entire group.

The llamas and alpacas may be looked upon as the best living representatives of the camel tribe in its primitive state, before it had begun specially to assume its camel-stage. They do not possess the adaptive peculiarities which fit the camel for its desert existence; and, on the other hand, they exhibit to the full that awkward, ungainly, misshapen type which so often betrays Nature's first rough draught of an evolving order. They are, as it were, the sketchy outline only of the perfected ruminants. Compare for a moment the ugly, shambling, ungraceful alpaca with the red deer, flying over the open Scotch moorland; the gazelle, springing lightly along the Syrian plains; the antelope, careering across the South African veldt; or the chamois, leaping from crag to crag among the frozen Alps, and you will see at once what is meant by the difference between a specialized and a generalized type—the difference between Nature's early attempts in a given line, and her fully evolved and carefully molded final product.

The antelopes and deer, with their various allies, such as the gnu, the eland, the ibex, the buffalo, the bison, the sheep, the bighorn, and the musk-ox, represent for us the developed ruminant types, produced by fierce competition in the struggle for life in the great continents. Their fleetness of foot, their exquisite horns, their agility, their grace of movement, all depend upon the existence in their native countries of highly evolved beasts of prey, from whose fierce attacks they have had to save themselves by speed and acuteness. To the same cause they owe also the keenness of their senses, the slimness of their legs, and to some extent also the elegance and beauty of their entire bodies. The smaller kinds, like the gazelles, are remarkable for their vigilance, their timidity, and their alertness, the hereditary result of ages spent in avoiding the attacks of predatory enemies. Natural selection, in short, has given to the advanced ruminants generally their distinctive rapidity, lightness, and beauty of shape. To sexual selection, on the other hand, they owe their twisted horns or branching antlers, their dappled coats and exquisite markings,

their ornamental manes and their proud and stately gait and carriage. All these points are wholly wanting in the clumsy llama and alpaca group. Stranded remnants, as it were, of the Eocene world, those antique creatures linger on among their mountain valleys a perpetual milestone by whose indications we may mark the progress since effected, under stress of selective agencies, in the main advancing body of the higher ruminants.

On such a simple original type, defenseless and ungainly, the camel is a specialized and adapted desert variation. The undeveloped llamas have no humps, and they have their two toes quite separated in a certain awkward, ungraceful, splay-footed fashion. In the true camels, on the other hand, the two toes are united below by a kind of horny sole, almost to their points, which terminate in a couple of small hoofs, and beneath the foot there is a soft cushion, by which the instep bears upon the sandy soil over whose expanses the creature is adapted to move. This padded sole is to the camel what the solid hoof is to the horse, it fits him exactly for the sort of ground over which his ancestors have stalked and shambled for countless generations. And it is interesting to note the similarities and differences which natural selection has brought about in the case of these two chief human beasts of burden.

In both the foot has become adapted for scouring the open plain only; firmness and sureness of tread have been the sole qualities that really told, and hence, in both, the toes as such have become practically extinct, and in their place one gets at last a single united broad-based foot, such as gives the animal the most secure foundation for his heavy body upon the level ground.

Compare for a moment these two types of practically toeless foot with the grasping hand of the forestine monkeys, the sharp claws of the tree-haunting squirrels, the light paw of the leaping hare, or even the slender and delicate ungulate feet of the gazelles and the chamois, and you will see how wholly they have been specialized for their work as trotters only. In the ruminants generally, as in all the great division of hoofed mammals, the extremities are calculated for support alone; but in the horse and in the camel this restriction of function reaches its highest practical point, and the feet and legs exist merely as adequate and extremely stable props for the heavy framework. In the horse the solid hoof remains as the sole surviving toe out of the original five possessed by his primitive ancestors in the American Eocene (though the "splint-bones," well known to the veterinaries, are the last functionless relics of two other toes); in the camel the same result is practically attained by the union of the two toes which it still possesses through the medium of a single horny sole, as well as by

throwing the main weight of the body on the padded cushion underneath the instep.

On the other hand, in the horse, adapted as he is by nature for scouring open, grassy plains or hill-sides, natural selection has favored the development of a particularly hard and solid hoof, whose native qualities man still further exaggerates by shoeing him with a clanking ring of iron; while in the camel, the direct product of desert conditions, a singular softness and pliability of foot has rather been encouraged by the soft and shifting nature of Saharan or Bactrian sands. For this reason, it is found practically that the horse and the camel are in any given country mutually exclusive; where the one thrives the other languishes. Here, in northern Africa, outside the Atlas, camels can not be profitably employed as beasts of burden; the few that come here in caravans from the desert arrive with a weary, foot-sore, dejected look, tired of tramping with their soft-padded feet over the hard and smooth macadamized roads which the French engineers have substituted for the narrow, paved Moorish packways, where mules and Arabs once transacted in their slow and lumbering fashion all the business of Algeria and Tunis. But beyond the shallow belt between the mountains and the sea the horse is of no avail: his hard and unyielding hoof sinks deep into the shifting sand of the desert, and he struggles and shuffles in helpless despair where the light dromedary, with his loose, shambling gait, his long trot, and his padded sole, fitting itself accurately to the sand beneath, accomplishes with ease his hundred miles a day for a week together. On hills or rocks the camel is nowhere, on open sandy plains he can hold his own against all comers.

It is interesting to note, indeed, how much alike in many adaptive particulars, but especially in their awkward gait, their tall necks, their long, shambling swing, and the powerful flanks which bring it about, are the three chief inhabitants of the desert or its outskirts—the camel, the giraffe, and the African ostrich. In the last-named case, the likeness is all the more curious and striking because one would almost have said beforehand that to adapt a bird and a ruminant mammal to the same environment, and to turn them out at last with many striking external resemblances of shape and gait, would be simply impossible; and yet Nature has accomplished this strange feat so perfectly that Linnæus, struck by the singular analogy between the two creatures, gave the ostrich the scientific name, which it still bears, of *Struthio camelus*. Even the reduction in the number of the toes to two, and their provision with a soft pad underneath, have been accurately reproduced in the great bird. As to the giraffe, its old name of camelopard sufficiently attests the popular appreciation of its outer similitude to the ship of the desert. The fact is, no

large animal can be properly adapted for Saharan conditions (liability to attack from lions and other great beasts of prey included), unless it combines these three attributes of a soft tread, a swift, swinging gait, and a long neck, enabling it to reach its food above or below, as necessitated by the height of its legs and body. Ostriches, giraffes, and camels alike, all feed to a considerable extent indeed on foliage of trees.

Of all these animals, however, the most purely desert-haunting is the camel itself, and it exhibits, therefore, a few special peculiarities not equally well developed in any other creature. In the first place, desert journeys imply continued privation, or even at times complete absence of food. Now, whenever in the animal kingdom such a necessity frequently arises in the ordinary life-history of a species, natural selection has provided against it by favoring the survival of those individuals which can lay up spare material against the period of famine in their own tissues. A starving sheep, Prof. Huxley well remarks, is as much a carnivore as the lion that would devour it; it subsists strictly upon its own fat and its own muscle, which it slowly unbuilds to use up in the needful action of its heart, its lungs, its limbs, and its internal organs generally. Hence, in hard times, those animals which have the largest reserve-fund of fat at their disposal will survive longest, and species which often encounter hard times learn organically by hereditary experience to supply such a reserve-fund against possible contingencies. Thus the bear and the dormouse go to sleep sleek and plump for the annual hibernation, and wake up mere loose and baggy masses of skin and bone. The zebu and other tropical oxen gather a huge hump of fat between the shoulders in the wet months while grass is plentiful, to serve them as a store of food during the dry season. But in the camel and dromedary this special provision against famine reaches the highest point, and produces the hump or humps on the back—one in the Arabian or African, two in the Bactrian or Indian variety.

Structurally, of course, the humps are nothing—mere lumps of fat, collected under a convenient fold of the skin, and utterly unprovided for in the framework of the skeleton. When the animal is at its best and well fed, they are full and plump, standing up on his back firm and upright; but on a long journey they are gradually absorbed to keep up the fires that work the heart and legs, and in the caravan camels which arrive at the coast, the skin hangs over, an empty bag, upon the creature's flanks, bearing witness to the scarcity of external food during the course of his long, forced march from the interior. A starved small camel in this state of health far more closely resembles a Peruvian llama than any one who has only seen the fine, well-kept beasts in European menageries or zoölogical gardens could readily imagine.

But water is even scantier in the desert than food; and against want of water, therefore, the camel has had to provide himself, functionally at least, if not structurally, quite as much as against want of herbage. His stomach has accordingly acquired the power of acting as an internal reservoir, and he can take in as much water at the Bahrs or Wadys, where he rests for a while on his toilsome march, as will supply his needs for four or five days together. There are some differences in this respect, however, between the two chief varieties of the camel. The African kind is most abstemious, and best adapted to sandy deserts; the Bactrian, a product of more varied and better-watered country, is larger and stronger, but less patient of hunger and thirst, while at the same time it can manage to subsist and to make its way into somewhat rockier and more rugged country.

One other adaptive peculiarity the camel possesses which marks it out essentially as a desert-born animal, modified for generations by the baking expanse of Sahara or the Arabian sand-wastes. On those scorching surfaces a horse could not lie down to rest in the eye of the sun without scalding or excoriating his tender skin. But all the parts of the camel's body which touch the sweltering sand in his ordinary patient kneeling position are provided with callosities of thickened hide, which enable him to rest on the burning surface without danger or discomfort. The only other desert-haunting ruminant of similar habits, the giraffe, has analogous callosities for the same purpose on his breast and knees. Such adaptive characters, however, are never a key to real relationship; they necessarily result from mere exposure to the same circumstances; and hence we get the seemingly paradoxical principle, so well enunciated by Mr. A. R. Wallace, that the more useful any organ or point of structure is to its possessor, the less is its value as a test of systematic position. Unseen little bones and internal organs, which fail to strike the imagination of the outside observer, are rightly used as the keys to underlying relationship by the systematic biologist. The real affinities of the camel are closest, indeed, not with the giraffe which so strongly resembles it, but with the llama and alpaca, so remotely connected in outer seeming, and so widely separated from it in space by an entire hemisphere.

Camels, llamas, and alpacas alike, then—to sum up the conclusion to which we have all along been tending—represent a very simple and early ruminant type, unmarked by any of those higher features induced in the ruminants of the open plains of the great continents by the necessity for protection from the advanced carnivores. They recall for us in their main points of structure, as well as in their low and undeveloped grade of intelligence, the general characteristics of the ruminant race at the dawn of its

existence in the Eocene period. They have no horns or tusks or weapons of offense, such as grow up in the savage battles of the males among dominant races; and their very docility and gentleness of demeanor result in the last resort from this undeveloped character of their entire class; for non-fighting animals are always timid, patient, and inoffensive, though often obstinate and self-willed to a noteworthy degree, as the camel can be whenever he chooses. Their virtues themselves thus tell against them; they betray the stupidity and the archaic, unprogressive character of the whole type. The *camelidæ* as a group, in short, are surviving specimens of the raw material from which, by natural and sexual selection, the higher ruminants, in diverging lines, have been slowly evolved through innumerable ages.

But of this antique and unspecialized type, the camel itself is in certain ways a highly modified and peculiarly adapted desert offshoot. Retaining still in its internal structure the marks of its early undeveloped character, it nevertheless presents in external configuration and functional peculiarities a remarkable instance of special adaptation to a restricted environment. While as a ruminant it is extremely low, as a desert animal it is at the very top of the tree. And it is this early adaptation to a very unusual mode of life that has enabled the camel, lowly as it is in general organization and in intellectual grade, to hold its own successfully against all later comers, and to preserve for us still in the great central Eurasiafrican continent a type of life otherwise extinct save in a single outlying and practically insulated district of the old South American life-region.—*Longman's Magazine.*

BELIEFS ABOUT THE SOUL.

By R. A. OAKES.

FROM the standpoint of primitive man it seems impossible for him to escape the conviction of a plurality of souls or the belief of their survival after death. Troubled by no psychical problems, accepting all things with an unreasoning faith, the phenomena of dreams, of coma attending swoons, of apoplexy, and of kindred afflictions, are explicable only on the supposition of a plural soul. He lies down on his rude couch, closes his eyes, and in an instant is living over the scenes of his daily life. He visits again far-distant hunting-grounds, renews once more the joys and fatigues of the chase, indulges in his savage warfare, and encounters adventures at once weird and abnormal. The dead—those who have for years been moldering in the earth—come back and speak to him, and renew once more the pleasures of his social

life. His body lies immovable, life and warmth remain with it, his breath comes and goes, his pulse throbs as in his waking hours, but he in the mean time has traversed leagues and leagues of forests, crossed broad rivers, scalped an enemy, or killed some savage wild beast. Upon the supposition of a dual soul, the mystery of his sleep is at once explicable. While one soul stays and watches over the body, the other soul has gone out to roam over the world at will.

This explanation of dreams seems to have received wide-spread recognition alike with the early civilized and savage races of men. The Chinese thought that the soul in dreams went out in a nightly ramble even to foreign lands. One day when the "spiritual man" of T'ih Kwalee, one of the gentry, was out roaming around, a wild beast found his body and ate it; so, when the spirit returned, it found only the skeleton, but fortunately near by was a beggar's corpse, black and lame; this he took as a substitute for his own body, and always afterward walked with a staff.* The Japanese believe that, if a sleeper is wakened suddenly and violently, he will die, because his soul is then rambling at a distance, and can not return to the body in time before it is awakened. This soul is supposed to have form and color, and to be a small, round, black body, and its adventures, when in the disembodied state, form a standard subject for Japanese novels and imaginative literature.† Pliny tells us that the soul of Hermotinus, one of the embodiments of Pythagoras, was in the habit of leaving his body and wandering into distant countries, whence it brought back numerous accounts of various things which could not have been obtained by any one but a person who was present. The body in the mean time was left apparently lifeless. At last his enemies burned the body, so that the soul on its return was, as it were, deprived of its sheath.‡ St. Augustine tells the story of a man who visited another and expounded a certain passage in Plato which formerly he had refused to do, and afterward, when questioned why he had changed his mind, denied that he had, but admitted that in a dream he had expounded the passage.# At the Temple of Isis, in Alexandria, an Egyptian priest, in the presence of Plotinus and his disciple Porphyry, drew a magical circle on the ground, decked out with the customary astrological signs, and then invoked from the body of Plotinus his own soul, so that he stood face to face with it.‖ Goethe^ positively asserts that he

* Du Bose, "Dragon, Image, and Demon," pp. 369, 422.

† Griffis, "The Mikado's Empire," p. 472.

‡ "Natural History," vol. vii, p. 53.

"De Civitate Dei," vol. xxviii, p. 18.

‖ Draper, "Intellectual Development of Europe," vol. i, p. 404.

^ Elam, "A Physician's Problems," p. 336.

had a similar experience. Aristophanes * tells us that Pisander betook himself to a certain lake to see his own soul, which had deserted him, evoked by Socrates.

The belief of savages in the possibility of the soul leaving the body during life has been widely traced. In western Africa, when a man wakes up with a pain in his body or muscles, it is because his spirit has wandered abroad in the night and been flogged by some other spirit.† The Feejeeans believe that the spirit of a man will leave the body to trouble other people when asleep, and, when any one faints or dies, his spirit can be brought back by calling after it.‡ Du Bose * tells us that in China often at night is heard the weird sound of a man calling back the body of a sick child. In the streets a cloth will be spread on the ground, with some beans thrown on it. An old woman stands by it, and calls the child by name: "Ah, do come back!" A voice up-stairs responds, "Ah!" Or the mother goes in front with a lighted lantern in hand, burning paper money at every corner. The father follows with the sick boy's clothing in his hat, crying, "My son, come back, come back!" An insect on the roof is caught, folded nicely in paper, and put beside the sick boy's pillow, and thus the lost soul is found. Sickness comes from losing his soul, and recovery follows its return home. Le Clerc recounts a story, current among the Algonquins, of an old Indian chief, whose favorite son having died, journeyed to the land of souls for his recovery. When once there, he begged so hard for his son's soul that the Indian Pluto finally gave it to him in the form and size of a nut, which, by pressing between his hands, he forced into a small leathern bag. Instructed to place the soul in the body of his son, who thereupon would come to life, the happy father hastened back, where he was greeted with dancing and rejoicing. Wishing to take part in these festivities, he handed the boy's soul for safe-keeping into the hands of a squaw. Tempted by a curiosity which has proved so fatal in all religious cults, the woman opened the bag to peep into it, when the soul escaped and returned to the land of the dead.‖ Turner ^ tells us that the soul of the chief Puepuemai was wrapped up and carried around in a leaf. The Ojibways describe how one of their chiefs died, but, while they were watching the body on the third night, his shadow came back into it, and he sat up and told them how he had traveled to the river of Death, but had been stopped there and sent back to his people.◊ The Malays do not like to wake a sleeper, lest they should hurt him by disturbing his body when his soul is out.

* "The Birds," p. 1553.
† Wilson, "Western Africa," chap. xii.
‡ Williams, "Fiji and Fijians," vol. i, p. 242.
* "Dragon, Image, and Demon," p. 443.
‖ Parkman, "Jesuits of North America," p. lxxxiii.
^ "Samoa," p. 142.
◊ Tylor, "Anthropology," p. 344.

Sir John Lubbock * has traced this belief in the power of the soul to leave and return to the body to the inhabitants of Madagascar, the Veddahs of Ceylon, the Mangaujas of South and the Yorubans of West Africa, the Tongans, the Peruvians, and other tribes.

Frequently the soul in its mundane journeyings took the visible guise of some animal. Grimm † tells us how King Gunthram's soul, while he slept on his faithful follower's lap, came out of his mouth in the form of a snake, and attempted to cross a stream. To aid the snake, the henchman bridges the stream with his sword, when it passes over, goes up a hill, and, after a little, returns and enters the king's mouth. Presently the king wakes, and relates how in a dream he had crossed an iron bridge, and entered a mountain filled with gold. Claud Paradin, ‡ in his "Symbola Heroica," has a variant of this wonderful dream, accompanying the legend with an engraving of a sword with a small animal—possibly a mouse—standing on the blade, and the motto "*Sic sopor irrupit.*" In this variant the king returns to his palace and summons all the wise men of his kingdom to interpret the dream, and for once in the world's history the opinions of the *savants* were unanimous. A large treasure was concealed in the hill, and its existence was thus revealed by a miracle.

Hugh Miller # illustrates the Celtic theory of dreams by a similar legend. Two young men sitting on a mossy bank overhanging a small cascade, one of them, overcome by the heat of the day, falls asleep, when his companion is surprised to see issue from his mouth a little indistinct form scarcely larger than a humble-bee, which disappears over the cascade. The watcher in alarm tries to waken his companion, but, before he succeeds, the cloud-like creature returns and enters the sleeper's mouth. Then he opens his eyes and relates a wonderful dream; how he crossed a broad river on a bridge of silver, and found on the further shore heaps of gold and jewels. It is more frequently the guise of a mouse that the wandering soul delights to masquerade in, though according to Grimm ‖ it is the devil's brides out of whose mouths the soul runs in the shape of a red mouse. Thus we are told that in Thuringia a servant-girl fell asleep while her companions were shelling nuts, when they observed a little red mouse creep out from her parted lips and run out of the window. One of those present then shook the sleeper, but, not succeeding in waking her, moved her to another place. Presently the mouse ran back to the former place, and dashed about, seeking the girl, but, not finding her, it vanished, when the girl instantly died.^ A miller, cutting fire-wood in the Black Forest, fell asleep over his work, when

* "Origin of Civilization," p. 214 *et seq.*
† "Teutonic Mythology," vol. iii, p. 1082.
‡ Chambers's "Book of Days," vol. i, p. 276.
# "Schools and Schoolmasters."
‖ Grimm, *loc. cit.*
^ Baring-Gould, "Curious Myths," p. 424.

his man saw a mouse creep out of his mouth and run away; every one searched for the animal, but could not find it, and the miller never awoke.* In Bohemia it was considered dangerous to go to sleep while thirsty, as the soul was sure to wander abroad in search of water. Baring-Gould † tells the story of three laborers, having lost their way in the woods, and, parched with thirst, seeking in vain for water. At last one of them lay down and fell asleep, while the others continued their search until they found a spring. After drinking they returned to their comrade, when they saw a little white mouse run out of his mouth, go to the spring, drink, and then return to the sleeper. In German superstition the souls of the dead assume the forms of mice, and when the head of a house dies it is said that even the mice of the house abandon it, and that, in general, every apparition of mice is considered a funereal presage; the funeral of St. Gertrude, represented surrounded by mice, being thus accounted for.‡

The position of the mouse in the folk-lore of the soul is not quite clear. The Mojaves believe that curling upward with the smoke from the funeral pyre the soul rises and floats eastward to the region of the rising sun; but, if its purity has been sullied with crime or stained with human blood, it is transformed into a rat and must remain four days in a rat-hole to be purified before it can share the joys of heaven.* Mr. Ralston‖ tells us that in the Nijogorod Government the Milky-Way is called the Mouse-Path, the mouse being a well-known figure of the soul. Miss Phipson△ says that the dormouse, from its awakening from sleep with the return of spring, was sometimes employed in ecclesiastical art as a type of the resurrection. *Per contra*, Mr. Conway ◊ assures us that the shudder which some nervous persons feel at the sight of even a harmless mouse is a survival of the time when it was believed that in this form unshriven souls or unbaptized children haunted their former homes, and from the many legends that report the departure of unhallowed souls in the shape of this timid creature.

Birds vie with mice in the honor of being human soul-bearers. The heathen Bohemians thought that the soul flew out of the mouths of the dying in the shape of birds. Grimm ‡ says such ideas were common in pagan Scandinavia. In the Edda of Sæmund it is said that souls in the form of singed birds flit about the nether world like swarms of flies. The Bohemians thought that bird-shaped souls flew restlessly from tree to tree until the bodies were

* Grimm, *loc. cit.*
△ "Animal Lore," p. 131.
† "Curious Myths," p. 461.
◊ "Demonology and Devil Lore," vol. i, p. 128.
‡ De Gubernatis, "Zoölogical Mythology," vol. ii, p. 67.
* Bancroft, "Native Races of the Pacific Coast," vol. iii, p. 526.
‖ "Songs of the Russian People," p. 109.
‡ "Teutonic Mythology," vol. ii, p. 828.

burned, when they had rest. The Finns and Lithuanians and later nearly all Indo-European people called the Milky Way the Birds' Way—that is, the way of souls.* The Moslems say that the souls of the faithful assume the form of snow-white birds, and nestle under the throne of Allah between death and the resurrection.† Another account says that in the intermediate state, until the resurrection, the souls of martyrs, according to tradition received from Mohammed, rest in heaven in the crops of beautiful green birds who eat of the fruits and drink of the rivers in that charmed region.‡ In China on the twenty-first day of the period of mourning for the dead three large paper birds resembling storks are placed on high poles in front of the house of mourning. These birds are supposed to carry the souls of the departed to Elysium, and during the next three days prayers are addressed to the ten kings of the Buddhist hades calling on them to hasten the flight of the departed soul to the Hindoo paradise.# On the Bosporus flocks of birds about the size of a thrush fly up and down the channel, and are never seen to rest on sea or land, and are believed by the boatmen to be the souls of the damned, condemned to perpetual motion.‖ Pliny^ tells that it is stated in Proconnesus that the soul of Aristeas was seen to fly out of his mouth under the form of a raven. The Aztecs believed that the souls of those killed in battle, of prisoners sacrificed by the enemy, and of women dying in childbirth, went to the sun, where they passed four years of delightful existence. They were then turned into birds and animated the clouds with their brilliant plumage and harmonious voices, free to rise to the vaults of heaven or to descend to earth to taste the nectar of the flowers.◊ When a Kailta dies it is thought that the soul is carried to the spirit-land by a little bird, and, if it has been a wicked soul, it is overtaken on the way and devoured by a hawk or other bird of prey.‡ Among the Apaches the owl, the eagle, and perfectly white birds were regarded as possessing souls of divine origin.‡ The Maricopas believe that after death they will return and live in their ancient homes on the banks of the Colorado River, where their heads will be turned into owls and the other parts of their bodies into different animals.‡ The Icannas of Brazil think the souls of the

* Kelley, "Indo-European Folk-Lore," p. 103.

† Brewer, "Dictionary of Phrase and Fable," p. 840.

‡ Koran, Sale, "Preliminary Discourse," section 4; Alger, "Future Life," p. 201.

Jones, "Credulities," p. 373.

‖ Hardwick, "Traditions, Superstitions, and Folk-Lore," p. 158.

^ "Natural History," vol. vii, p. 53.

◊ Bancroft, "Native Races," vol. iii, p. 533; Alger, "Future Life," p. 73; Biart, "The Aztecs," p. 86.

‡ Joaquin Miller, "Among the Modocs," p. 241.

‡ Schoolcraft, "Archæology," vol. v, p. 209.

‡ Bartlett, "Personal Narrative of Exploration," vol. ii, p. 222.

dead become beautiful birds feeding on luscious fruit.* The Powhatans sacredly regard small wood-birds, thinking they inshrine the souls of their dead.† Among the Aht tribes it is believed that the soul issued from gulls and partridges, and that they will after death return to their original forms.‡ The Hurons, according to Brebeuf,* believed that the souls of the dead turned to doves; and among the cognate tribes of the Iroquois a dove was freed over the couch of the dying at the moment the last breath was drawn.‖ The Paris "Figaro" for October, 1872, gives an account of a similar observance as happening in the Rue Duhesme of that city. A young gypsy woman when dying was surrounded by her companions, when a man, who appeared to be the chief, entered the circle, carrying a bird in his hand, which he held beneath the mouth of the dying, and freed when she expired.^

The providing the dead with passports or money with which to lighten the journey of the soul to heaven is wide-spread. The Greeks placed an obolus in the mouth of the corpse, as toll for Charon, though this offering was omitted at Hermione, in Argolis, where men thought there was a short descent to hades, and thus avoided the fee.◊ Becker‡ doubts if this custom was universal among the Romans, the passages of Juvenal, vol. iii, p. 67, and of Propertius, vol. iv, pp. 11, 7, affording no sufficient proof. Among the Chinese, money was put into the mouth of the dead to buy favor in the passage to heaven.‡ In Washington Territory, in 1879, the mouth of a dead Twana squaw was filled with money before burial.‡ At the present day, all over Europe at Irish wakes money is placed in the hand of the dead.** In Tuhkeim, the soul of the dead, having crossed the bridge leading out of hell with the aid of the priests, receives a letter of recommendation from them favoring its admittance into the western heaven.†† The dead of the ancient Mexicans were furnished with several passports, the first one enabling the soul to pass between two mountains, which threatened to meet and crush it in their embrace; the second enabling it to pass the road guarded by a big snake; the third propitiated Xochitonal, the green crocodile; and the fourth insured the passage across eight deserts and over eight hills.‡‡

That the soul materializes in the shape of the body it inhabited

* Clavigero, "Messico," vol. ii, p. 5.
* "Rel. des Jesuits," 1636, p. 4.
† Brinton, "Myths of the New World," p. 107.
‖ Morgan, "League of the Iroquois," p. 174.
‡ Bancroft, "Native Races," vol. iii, p. 522.
^ Jones, "Credulities," p. 380.
◊ Tylor, "Primitive Culture," vol. i, p. 490.
‡ "Gallus," Excursus xii.
‡ Ball, in Williams's "Middle Kingdom," vol. ii, p. 244, note.
‡ "American Antiquary," October, 1880, p. 53.
** Tylor, "Anthropology," p. 347.
†† Du Bose, "Dragon, Image, and Demon," p. 452.
‡‡ Bancroft, "Native Races," vol. iii, p. 537.

while on earth is one of the tenets of modern spiritualism. The Chinese believe that decapitation makes headless souls in hades. During the T'aiping troubles as much as six hundred and sixty-six dollars was paid for a head to be buried with a body, in order to make a respectable appearance in the other world!* The Australian who has slain his enemy will cut off the right thumb of the corpse, so that it can not throw the ghostly spear with the mutilated hand. A West India planter, whose slaves were committing suicide in order that they might come to life in their native land, cut off the heads and hands of the corpses, thus effectually putting an end to the practice.† In China the souls of the drowned are supposed to remain under water for three years, when they seize the shadow of some passing man, pull him in, and thus effect their own escape. Boatmen are in continual dread of these demons, and stone pillars are erected on the spots where they were drowned in order to control their souls.‡ Damascius tells us that, in a battle fought near Rome by Valentinian against Attila, the slaughter on both sides was so great that none escaped, and, when the bodies had all fallen, the souls still stood upright and continued fighting three whole days and nights, neither inferior in activity of hands or fierceness of mind to living men. The images of the soul were seen and the clashing of their armor heard.*

The idea of the plurality of the soul is met with in the oldest records of man, and is universally accepted by savage tribes to-day. The Egyptians considered man to have a soul, *ba*, represented by a hawk with a human head; a shade, *khebi;* a spirit or intelligence, *khu*, into which it became changed as a "being of light"; an existence, *ka;* besides life, *ankh*. The soul, *ba*, only revisited the body.‖ The Hebrews have *nepesh*, the animal life; *ruah*, the human principle of life; and *neshamah*, life considered as an inspiration of the Almighty, and from these the Rabbins taught the threefold nature of the soul.△ The Persians divided the soul into five parts: The *feroher*, or sensation; the *boo*, intelligence; the *rough*, imagination, volition; the *akho*, conscience; and the *jan*, animal life. Of these, the first one alone was accountable for the deeds done in the body.◊ The Chinese believe in three souls and six spirits: the latter, being animal, go down into the earth at death, while, of the souls, one goes down into

* Williams's "Middle Kingdom," vol. ii, 244.

† Tylor, "Primitive Culture," vol. i, p. 451.

‡ Du Bose, "Dragon, Image, and Demon," p. 454.

* Southey, "Commonplace-Book," vol. i, p. 287.

‖ Birch, in Wilkinson's "Ancient Egypt," vol. iii, p. 465, note.

△ Farrar, "Language," p. 188.

◊ Fraser, "History of Nadir Shah"; cf. Emerson, "Indian Myths," p. 179.

hades, the second enters the coffin, and is laid in the grave, but is not satisfied with its dismal abode; while the third lingers around its old home, and with the second soul receives the worship of its posterity.* The Hindoos designate between *Brahmâtmah*, the breath of God, and *jivâtmah*, the breath of life.† The Khonds of Orissa have a fourfold division of the soul, the first soul being absorbed by the Boora, or deity, the second is reborn into succeeding generations, the third goes out in dreams, and the fourth dies with the body.‡

Plato located in the human body three souls, the rational and immortal soul occupying the head, the lower souls occupying respectively the region near the heart and the abdominal region below the diaphram, the latter subject to and connected with the higher by being fastened to the spinal marrow or cord. Of these lower souls, the thoracic was the seat of energy and anger, while to the abdominal soul belonged the appetites, the desires, and the greed of gain.* Aristotle divided the soul into the vegetative, the perceptive, the locomotive, the impulsive, and the noetic, all but the latter being shared with animals, while the *nous* was divine, perhaps pre-existent and imperishable.‖ Among the Romans the question of the plural soul is open to discussion. Ovid says: "The shades flit round the tomb; the underworld receives the image; the spirit seeks the stars" (*Tumulum circumvolat umbra; orcus habet manes; spiritus astra petit*). In his "Tristia"^ he complains that, while his immortal spirit soars aloft into the vacant air, his shade will be wandering amid Sarmatian ghosts. Hardonin◊ says that the Romans made a distinction between the souls of the dead and their shades, *umbræ*. The former were supposed to remain on earth, while the latter were removed either to Elysium or Tartarus, according to the character or actions of the deceased. That the idea of a triple soul lingered in England we know from Sir Toby Belch, in Shakespeare's "Twelfth Night," asking, "Shall we rouse the night-owl with a catch that will draw three souls out of one weaver?" Nares‡ says that the peripatetic philosophy, which governed the schools in the time of the old English dramatists, assigned to every man three souls—the vegetative, the animal, and the rational. In his quaint "Letters,"‡ Howell tells us that the embryon is animated with three souls:

* Du Bose, "Dragon, Image, and Demon," p. 81; Williams, "The Middle Kingdom," vol. ii, p. 243.

† Farrar, *loc. cit.*

‡ McPherson, "India," p. 91.

* Plato, "Timæus"; Grote's "Plato," vol. iii, p. 271, 272; Bain, "Senses and Intellect," p. 613.

‖ Cf. "De Gen. et Cor.," vol. ii, p. 3; "De Anima," vol. iii, p. 5.

^ Vol. iii, p. 3.

◊ Pliny, "Natural History," vol. vii, p. 57, note.

‡ "Glossary," vol. ii, p. 817.

‡ I., vol. iii, p. 36.

with that of plants, called the vegetable soul; then with the sensitive, which all brute animals have; and, lastly, the rational soul is infused; and these three in man, he adds, are like Trigonus in Tetragono.

The Iroquois and Algonquins believed that the soul which gave bodily life was of a vegetative character, and remained with the corpse after death until it was released by being reborn into another body; while the ethereal soul, which roamed at will while the body was asleep or in a trance, after death departed directly to the land of spirits.* Infants were buried by the sides of paths, that their vegetative souls might enter into the body of some mother, and their rebirth thus be hastened.† Among the Tucullus the medicine-man placed his hands over the breast of the dying, and then, holding them over the head of a relative, blew through the expanded fingers, in order that the next child born to him might be the representative of the departed.‡ Certain tribes on the Pacific coast believed that one of the souls had its dwelling in the bones, and, if these were planted, they would germinate like seed, and produce human beings.* The Choctaws believe that every man has an outside shadow, *shilombish*, and an inside shadow, *shilup*, both of which survived his body.‖ The Sioux believed in three souls, one of which went to the cold world, another to the warm world, while the third remained and watched over the body.^ Mrs. Eastman ◊ tells us that the Dakotas extended the number of souls to four, one of which wanders through the world, another hovers around the village where its possessor lived, the third stays by the grave, and the fourth goes to heaven. With certain Greenlanders one soul took the form of a shadow, the other that of the breath.‡ The Feejeeans distinguished between a man's dark spirit or shadow, which goes down to hades, and his light spirit, the one that is reflected in water or a mirror, and which remains when he dies.‡ The Malagasy say that the *saina*, or mind, vanishes at death; the *aina*, or life, becomes mere air; while the *maloatoa*, or ghost, hovers around the tomb.‡

* "Rel. des Jesuits," 1636, p. 104.

† *Ibid.*, 1635, p. 130.

‡ Waitz, "Anthropology," vol. iii, p. 95.

* Bancroft, "Native Races of the Pacific Coast," vol. iii, p. 514.

‖ Brinton, "Myths of the New World," p. 251.

^ "Hist. Coll. Louisiana," vol. iii, p. 26.

◊ "Legends of the Sioux," p. 129.

‡ Tylor, "Primitive Culture," vol. i, p. 432; Spencer, "Principles of Sociology," vol. i, p. 191.

‡ Williams, "Fiji and the Fijians," vol. i, p. 241.

‡ Ellis, "Madagascar," vol. i, 393.

THE HISTORY OF A DOCTRINE.*

By Prof. S. P. LANGLEY.

I.

IN these days, when a man can take but a very little portion of knowledge to be his province, it has become customary that your president's address shall deal with some limited topic, with which his own labors have made him familiar; and accordingly I have selected as my theme the history of our present views about radiant energy, not only because of the intrinsic importance of the subject, but because the study of this energy in the form of radiant heat is one to which I have given special attention.

Just as the observing youth, who leaves his own household to look abroad for himself, comes back with the report that the world, after all, is very like his own family, so may the specialist, when he looks out from his own department, be surprised to find that, after all, the history of the narrowest specialty is amazingly like that of scientific doctrine in general, and contains the same lessons for us. To find some of the most useful ones, it is important, however, to look with our own eyes at the very words of the masters themselves, and to take down the dusty copy of Newton, or Boyle, or Leslie, instead of a modern abstract; for, strange as it may seem, there is something of great moment in the original that has never yet been incorporated into any encyclopædia, something really essential in the words of the man himself which has not been indexed in any text-book, and never will be.

It is not for us, then, here to-day, to try—

> "How index-learning turns no student pale,
> Yet holds the eel of science by the tail";

but, on the contrary, to remark that from this index-learning, from these histories of science and summaries of its progress, we are apt to get wrong ideas of the very conditions on which this progress depends. We often hear it, for instance, likened to the march of an army toward some definite end; but this, it has seemed to me, is not the way science usually does move, but only the way it seems to move in the retrospective view of the compiler, who probably knows almost nothing of the real confusion, diversity, and retrograde motion of the individuals comprising the body, and only shows us such parts of it as he, looking backward from his present standpoint, now sees to have been in the right direction.

I believe this comparison of the progress of science to that of

* President's address before the American Association for the Advancement of Science, at Cleveland, Ohio, August 15, 1888. Reprinted from "Science."

the army which obeys an impulse from one head has more error than truth in it; and, though all similes are more or less misleading, I would almost prefer to ask you to think rather of a moving crowd, where the direction of the whole comes somehow from the independent impulses of its individual members, not wholly unlike a pack of hounds, which, in the long run, perhaps catches its game, but where, nevertheless, when at fault, each individual goes his own way by scent, not by sight, some running back and some forward; where the louder-voiced bring many to follow them, nearly as often in a wrong path as in a right one; where the entire pack even has been known to move off bodily on a false scent; for this, if a less dignified illustration, would be one which had the merit of having a considerable truth in it, but one left out of sight by the writers of books.

At any rate, the actual movement has been tortuous, or often even retrograde, to a degree of which you will get no idea from the account in the text-book or encyclopædia, where, in the main, only the resultant of all these vacillating motions is given. With rare exceptions, the backward steps—that is, the errors and mistakes, which count in reality for nearly half, and sometimes for more than half the whole—are left out of scientific history; and the reader, while he knows that mistakes have been made, has no just idea how intimately error and truth are mingled in a sort of chemical union, even in the work of the great discoverers, and how it is the test of time chiefly which enables us to say which is progress when the man himself could not. If this be a truism, it is one which is often forgotten, and which we shall do well to here keep before us.

This is not the occasion to review the vague speculations of the ancient natural philosophers from Aristotle to Zeno, or to give the opinion of the school-men on our subject. We take it up with the immediate predecessors of Newton, among whom we may have been prepared to expect some obscure recognition of heat as a mode of motion, but where it has been, to me at least, surprising, on consulting their original works, to find how general and how clear an anticipation of our modern doctrine may be fairly said to exist. Whether this early recognition of the atomic and vibratory theories be a legacy from the Lucretian philosophy, it is not necessary to here consider. The interesting fact, however it came about, is the extent to which seventeenth-century thought is found to be occupied with views which we are apt to think very recent.

Descartes, in 1664, commences his "Le Monde" by a treatise on the propagation of light, and what we should now call radiant heat, by vibrations, and further associates this view of heat as motion with the distinct additional conception that in the cause

of light and radiant heat we may expect to find something quite different from the sense of vision or of warmth; and he expresses himself with the aid of the same simile of sound employed by Draper over two hundred years later. The writings of Boyle on the mechanical production of heat contain illustrations (like that of the hammer driving the nail, which grows hot in proportion as its bodily motion is arrested) which show a singularly complete apprehension of views we are apt to think we have made our own; and it seems to me that any one who consults the originals will admit that, though its full consequences have not been wrought out till our own time, yet the fundamental idea of heat as a mode of motion is so far from being a modern one, that it was announced in varying forms by Newton's immediate predecessors, by Descartes, by Bacon, by Hobbes, and in particular by Boyle, while Hooke and Huygens merely continue their work, as at first does Newton himself.

If, however, Newton found the doctrine of vibrations already, so to speak, "in the air," we must, while recognizing that in the history of thought the new always has its root in the old, and that it is not given even to a Newton to create an absolutely new light, still admit that the full dawn of our subject properly begins with him, and admit, too, that it is a bright one, when we read in the "Optics" such passages as these: "Do not all fixed bodies, when heated beyond a certain degree, emit light and shine, and is not this emission performed by the vibrating motions of their parts?" And again: "Do not several sorts of rays make vibrations of several bignesses?" And still again: "Is not the heat conveyed by the vibrations of a much subtler medium than air?"

Here is the undulatory theory; here is the connection of the ethereal vibrations with those of the material solid; here is "heat as a mode of motion"; here is the identity of radiant heat and light; here is the idea of wave-lengths. What a step forward this first one is! And the second?—the second is, as we now know, backward. The second is the rejection of this, and the adoption of the corpuscular hypothesis, with which alone the name of Newton (a father of the undulatory theory) is, in the minds of most, associated to-day.

Do not let us forget, however, that it was on the balancing of arguments from the facts then known that he decided, and that perhaps it was rather an evidence of his superiority to Huygens, that apprehending before the latter, and equally clearly, the undulatory theory, he recognized also more clearly that this theory, as then understood, failed utterly to account for several of the most important phenomena. With an equally judicial mind, Huygens would perhaps have decided so too, in the face of difficulties, all of which have not been cleared up even to-day.

These two great men, then, each looked around in the then darkness as far as his light carried him. All beyond that was chance to each; and Fate willed that Newton, whose light shone further than his rival's, found it extend just far enough to show the entrance to the wrong way. He reaches the conclusion that we all know; and with the result on other men's thought that, light being conceded to be material, heat, if affiliated to light, must be regarded as material too, for we may see this strange conclusion drawn from experiments of Herschel a century later.

It would seem that the result of this unhappy corpuscular theory was more far-reaching than we commonly suppose, and that it is hardly too much to say that the whole promising movement of that age toward the true doctrine of radiant energy is not only arrested by it, but turned the other way; so that in this respect the philosophy of fifty years later is actually further from the truth than that of Newton's predecessors.

The immense repute of Newton as a leader, on the whole so rightly earned, here leads astray others than his conscious disciples, and, it seems to me, affects men's opinions on topics which appear at first far removed from those he discussed. The adoption of phlogiston was, as we may reasonably infer, facilitated by it, and remotely Newton is, perhaps, also responsible in part for the doctrine of caloric a hundred years later. After him, at any rate, there is a great backward movement. We have a distinct retrogression from the ideas of Bacon and Hobbes and Boyle. Night settles in again on our subject almost as thick as in the days of the school-men, and there seems to be hardly an important contribution to our knowledge, in the first part of the eighteenth century, due to a physicist.

"Physics, beware of metaphysics," said Newton—words which physicists are apt so exclusively to quote, that it seems only due to candor to observe that the most important step, perhaps, in the fifty years which followed the "Optics," came from Berkeley, who, reasoning as a metaphysician, gave us during Newton's lifetime a conception wonderfully in advance of his age. Yet the "New Theory of Vision" was generally viewed by contemporary philosophers as only an amusing paradox, while "coxcombs vanquish[ed] Berkeley with a grin"; and this contribution to science —an exceptional if not a unique instance of a great physical generalization reached by *a priori* reasoning—though published in 1709, remains in advance of the popular knowledge even in these closing years of the nineteenth century.

In the mean time a new error had risen among men—a new truth, as it seemed to them, and a thing destined to have a strong reflex action on the doctrine of radiant energy. It began with the generalization of a large class of phenomena (which we now asso-

ciate with the action of oxygen, then of course unknown)—a generalization useful in itself, and accompanied by an explanation which was not in its origin objectionable. Let us consider, in illustration, any familiar instance of oxidation, and try to look first for what was reasonable in the eighteenth-century views of the cause of such phenomena. A piece of dry wood has in it the power of giving out heat and light when set on fire; but after it is consumed there is left of it only inert ashes, which can give neither. Something, then, has left the wood in the process of becoming ashes; virtue has gone out of it, or, as we should say, its potential energy has gone.

This is, so far, an important observation, extending over a wide range of phenomena, and, if it had presented itself to the predecessors of Newton, it would probably have been allied to the vibratory theories, and become proportionately fruitful. But to his disciples, and to chemists and others who, without being perhaps disciples, were, like all then, more or less consciously influenced by the materiality of the corpuscular theory, it appeared that this also was a material emanation, that this energy was an actual ingredient of the wood—a crudeness of conception which seems most strange to us, but it is not, perhaps, unaccountable in view of the then current thought.

I have said that the progress of science is not so much that of an army as of a crowd of searchers, and that a call in a false direction may be responded to, not by one only, but by the whole body. In illustration, observe that during the greater part of the entire eighteenth century this doctrine was adopted by almost every chemist and by most physicists. It had quite as general an acceptance among scientific men then as the kinetic theory of gases, for instance, has now, and, as far as time is any test of truth, it was tested more severely than the kinetic theory has yet been; for it was not only the lamp and guide of chemists, and, to a great extent, of physicists also, but it remained the time-honored and highest generalization of chemico-physical science for over half a century, and it was accepted not so much as a conditional hypothesis as a final guide and a conquest for truth which should endure always. And now where is it? Dissipated so utterly from men's minds that, to the unprofessional part of even an educated audience like this, "phlogiston," once a name to conjure with, has become an unmeaning sound.

There is no need to insist on the application of the obvious moral to hypotheses of our own day. I have tried to recall for a moment all that "phlogiston" meant a little more than a hundred years ago, partly because it seems to me that, though a chemical conception, physics is not wholly blameless for it, but chiefly because before it quitted the world it appears to have returned to

physics the wrong in a multiplied form by generating an offspring especially inimical to true ideas about radiant heat, and which is represented by a yet familiar term. I mean "caloric."

This word is still used loosely as a synonym for heat, but has quite ceased to be the very definite and technical term it once was. To me it has been new to find that this so familiar word "caloric," so far as my limited search has gone, was apparently coined only toward the last quarter of the last century. It is not to be found in the earliest edition of Johnson's Dictionary, and, as far as I can learn, appears first in the corresponding French form in the works of Fourcroy. It expressed an idea which was the natural sequence of the phlogiston theory, and which is another illustration that the evil which such theories do lives after them.

"Caloric" first seemingly appears, then, as a new word coined by the French chemists, and meant originally to signify the unknown cause of the sensation heat, without any implication as to its nature. But words, we know, though but wise men's counters, are the money of fools; and this one very soon came to commit its users to an idea which was more likely to have had its origin in the mind of a chemist at that time than of any other—the idea of the cause of heat as a material ingredient of the hot body; something not, it is true, having weight, but which it would have been only a slight extension of the conception to think might one day be isolated by a higher chemical art, and exhibited in a tangible form.

We may desire to recognize the perverted truth which usually underlies error, and gives it currency, and be willing to believe that even "caloric" may have had some justification for its existence; but this error certainly seems to have been almost altogether pernicious for nearly the next eighty years, and down even to our own time. With this conception as a guide to the philosophers of the last years of the eighteenth century, it is not, at any rate, surprising if we find that at the end of a hundred years from Newton the crowd seems to be still going constantly further and further away from its true goal.

Although Provost gave us his most material contribution about 1790, we have, it seems to me, on the whole, little to interest us during that barren time in the history of radiant energy called the eighteenth century—a century whose latter years are given up, till near its very close, to bad *a priori* theories in our subject, except in the work of two Americans; for in the general dearth, at this time, of experiments in radiant heat, it is a pleasure to fancy Benjamin Franklin sitting down before the fire, with a white stocking on one leg and a black one on the other, to see which leg would burn first, and to recall again how Benjamin

Thompson (Count Rumford) not only weighed "caloric" literally in the balance and found it wanting, but made that memorable experiment in the Munich foundries which showed that heat was perpetually and without limit created from motion.

It was in the last years of the century, too, that he provided for the medal called by his name, and which, though to be given for researches in heat and light, has, I believe, been allotted in nearly every instance to men who, like Leslie, Malus, Davy, Brewster, Fresnel, Melloni, Faraday, Arago, Stokes, Maxwell, and Tyndall, have contributed toward the subject of radiant energy in particular.

We observe that till Rumford's time the scientific literature of the century scarcely considers the idea even of radiant heat, still less of radiant energy; so that we have been obliged here to discuss the views of its physicists about heat in general, heat and light in most eighteenth-century minds being distinct entities. We must remember, then, to his greater honor, that the idea of radiant heat as a separate study has before Rumford scarcely an existence; all the ways for pilgrims to this special shrine of truth being barred, like those in Bunyan's allegory, by two unfriendly monsters who are called Phlogiston and Caloric, so that there are few scientific pilgrims who do not pay them toll.

The doctrine of caloric is, however, even then recognized as a chemical hypothesis rather than one acceptable to physicists, some of whom still stand out for vibratory theories even through the darkest years of the century; and, further, we may find, on strict search, that the old idea of heat as a mode of motion has not so utterly died that it does not appear here and there during the last century, not only among philosophers, but even in a popular form.

In an old English translation of Father Regnault's compilation on physics, dated about 1730, I find the most explicit statement of the doctrine of heat as a mode of motion. Here heat is defined (with the aid of a simile due, I believe, to Boyle) as "any Agitation whatever of the insensible parts. Thus a Nail which is drove into the Wood by the stroke of a Hammer does not appear to be hot, because its immediate parts have but one common Movement. But should the Nail cease to drive, it would acquire a sensible Heat, because its insensible Parts which receive the Motion of the Hammer now acquire an agitation every way rapid." We certainly must admit that the user of this illustration had just and clear ideas; and the interesting point here appears to be, that as Father Regnault's was not an original work, but a mere compendium or popular scientific treatise of the period, we see, if only from this instance, that the doctrine of heat as a mode of motion was not confined to the great men of an earlier or a later

time, but formed a part of the common pabulum during the eighteenth century to an extent that has been singularly forgotten.

The last years of the eighteenth century were destined to see the most remarkable experiments in heat made in the whole of the hundred; for the memoir of Rumford appeared in the "Philosophical Transactions" for 1798; and in the very year 1800 appeared in the same place Sir William Herschel's paper, in which he describes how he placed a thermometer in successive colors of the solar spectrum, finding the heat increase progressively from the violet to the red, and increase yet more beyond the red where there was no color or light whatever; so that there are, he observes, invisible rays as well as visible. More than that, the first outnumber the second; and these dark rays are found in the very source and fount of light itself. These dark rays can also be obtained, he observes, from a candle or a piece of non-luminous hot iron, and, what is very significant, they are found to pass through glass, and to be refracted by it like luminous ones.

And now Herschel, searching for the final verity through a series of excellent experiments, asks a question which shows that he has truth, so to speak, in his hands—he asks himself the great question whether heat and light be occasioned by the same or different rays.

Remember the importance of this (which the querist himself fully recognized); remember that, after long hunting in the blindfold search, he has laid hands, as we now know, on Truth herself, and then see him—let go. He decides that heat and light are not occasioned by the same rays, and we seem to see the fugitive escape from his grasp, and not to be again fairly caught till the next generation. I hardly know more remarkable papers than these of Herschel's in the "Philosophical Transactions" for 1800, or anything more instructive in little men's successes than in this great man's failure, which came in the moment of success. I would strongly recommend the reading of these remarkable original memoirs to any physicist who knows them only at second hand.

One more significant lesson remains, in the effect of this on the minds of his contemporaries. Herschel's observation is to us almost a demonstration of the identity of radiant heat and light; but now, though the nineteenth century is opening, it is with the doctrine still in the minds of most physicists, and perhaps of all chemists, that heat is occasioned by a certain material fluid. Phlogiston is by this time dead or dying, but caloric is very much alive, and never more perniciously active than now, when, for instance, years after Herschel's observation, we find this cited as "demonstrating the existence of caloric," which was, it seems, the way it looked to a contemporary.

In the year 1804 appeared what should be a very notable book in the history of our subject, written by Sir John Leslie, whose name survives perhaps in the minds of many students chiefly in connection with the "cube," which is still called after him. Leslie, however, ought to be remembered as a man of original genius, worthy to be mentioned with Herschel and Melloni; and his, too, is one of the books which the student may be recommended to read, at least in part, in the original; not so much for the writer's instructive experiments (which will be found in our text-books) as for his most instructive mistakes, which the text-book will probably not mention.

He began by introducing the use of the simple instrument which bears his name, and a new and more delicate heat-measure (the differential thermometer); and with these, and concave reflectors of glass and metal, he commenced experiments in radiant heat, than which, he tells us, no part of physical science then appeared so dark, so dubious, and so neglected. It is interesting, and it marks the degree of neglect he alludes to, that his first discovery was that different substances have different radiating and absorbing powers. It gives us a vivid idea of the density of previous ignorance, that it was left to the present century to demonstrate this elementary fact, and that Leslie, in view of such discoveries, says, "I was transported at the prospect of a new world emerging to view."

Next he shows that the radiating and absorbing powers are proportional, next that cold as well as heat seems to be radiated, and next undertakes to see whether this radiant heat has any affinity to light. He then experiments in the ability of radiant heat to pass through a transparent glass, which transmits light freely, and thinks he finds that none does pass. Radiant heat with him seems to mean heat from non-luminous sources; and the ability or non-ability of this to pass through glass is to Leslie and his successors a most crucial test, and its failure to do so a proof that this heat is not affiliated to light.

Let us pause a moment here to reflect that we are apt to unconsciously assume, while judging from our own present standpoint where past error is so plain, that the false conclusion can only be chosen by an able, earnest, conscientious seeker, after a sort of struggle. Not so. Such a man is found welcoming the false with rapture as very Truth herself. "What, then," says Leslie, "is this calorific and frigorific fluid after which we are inquiring? It is not light, it has no relation to ether, it bears no analogy to the fluids, real or imaginary, of magnetism and electricity. But why have recourse to invisible agents? *Quod petis, hic est.* It is merely the ambient AIR."

The capitals are Leslie's own, but ere we smile with superior

knowledge let us put ourselves in his place, and then we may comprehend the exultation with which he announces the identity of radiant heat and common air, for he feels that he is beginning a daring revolt against the orthodox doctrine of caloric, and so he is.

[*To be continued.*]

INFANT MORTALITY AND THE ENVIRONMENT.

By J. M. FRENCH, M. D.

IT is a startling fact, which meets the student of vital statistics at the outset of his investigations, that from one third to one half of all persons born into the world die before reaching the age of five years. Or, to face the terrible reality from another point of view, so great are the dangers of infancy, that a child which has completed its fifth year actually has an expectation of life more than twelve years greater than it had at birth.

The exact proportion of deaths varies greatly in different countries and localities, at different times and under different circumstances. Statistics are of value only in showing average results. In Norway, for example, the proportion dying under five is stated by Dr. Farr to be 204·5 per 1,000 born; while in England it is 338 per 1,000, and in Italy 567 per 1,000. In fifty-one so-called "healthy districts" of England and Wales, according to the same authority, the mortality under five is 175 per 1,000 born, while in the Liverpool district, representing the most unfavorable sanitary conditions, it is 460 per 1,000.

In the different parts of our own country, we find nearly as great a variety as on the continent of Europe. Even in the same latitude, the proportion varies greatly, according as city or country districts are considered. In the State of Vermont, which contains no large cities, and represents essentially a rural population, the number of deaths under five, for the year 1883, was 23·8 per cent of the whole number of deaths; in the State of Massachusetts, which embraces several large cities within its limits, for the twelve years ending in 1884, it was 34·74 per cent; and in the city of New York alone, for the seven years ending in 1873, it was exactly 50 per cent of the entire mortality.

The younger the child, the larger is the death-rate. According to Dr. Jacobi, more than half of those who die under five years of age die in the first year. Dr. Curtiss states that, in all the great cities of North America, out of every one hundred live-born children, about twenty-five die before the end of the first year, and from forty to fifty before the close of the fifth year.

Death-rates like these—and the figures might be multiplied

indefinitely—challenge our earnest attention and demand our careful consideration. Let us first inquire what are the diseases which are the immediate cause of the great bulk of infant mortality. These may be grouped in four main classes, namely:

(1) *The acute infectious zymotics*, of which the chief are measles, scarlet fever, small-pox, diphtheria, and whooping-cough. These are collectively responsible for from fifteen to twenty per cent of the deaths under five.

(2) *The acute lung-diseases*, chiefly bronchitis and pneumonia, which together cause from ten to fifteen per cent of the deaths under five. In America, more than twice as many deaths occur from pneumonia as from bronchitis, while in England nearly the reverse is true.

(3) *Tubercular and constitutional diseases*, such as consumption, scrofula, meningitis, and hydrocephalus, which are responsible for from ten to fifteen per cent of the entire infant mortality.

(4) *The diarrhœal diseases*, comprising infantile diarrhœa, cholera infantum, inflammation of the bowels, dysentery, and some others. These are the cause of at least one fourth of the entire infant mortality the world over; while in America cholera infantum alone is responsible for nearly or quite one fifth.

But the problem before us is not one which can be solved by a simple rehearsal of the names of diseases and the number of their victims. These only show the form and manner of death, while the ultimate causes lie far in the background.

The real questions at issue relate to those influences which are at work upon so large a proportion of infants and young children the world over, tending to break down in them the power of resisting disease, lessen their chances of a vigorous, healthy life, and render them unduly liable to go down to early graves. What is the nature of these influences? What circumstances tend to increase their activity? Under what conditions and to what extent may they be rendered inert, or their usual dire effects be avoided? By what means may an unfavorable environment be changed to a favorable one, and the vitality and longevity of the race be thereby increased?

In considering these questions, it must be remembered that the causes of infant mortality are also the causes of adult mortality, only in a less degree; and that the health of a delicate infant is the most sensitive measure which we possess of those influences which are deleterious to health, either in infancy or adult life.

The first of these deleterious influences in the order of time, and unquestionably also of importance, is *heredity*. A very large proportion of all children born into the world are either weaklings or invalids from the beginning. They are born wrong. They come from poor stock. The influences which determine their weakness

to-day have been at work for ages upon ages. That was no sarcasm, but the plainest statement of scientific truth, on the part of Oliver Wendell Holmes, when, after declaring his conviction that every disease might be cured if taken in season, he added, significantly, that in some cases it would be necessary to begin a hundred years before the patient was born. This is a hard world, and no weakling ever has half a chance. "The survival of the fittest" is a merciful provision of nature. "The strongest live and the weakest die." A race of criminals, paupers, and idiots deteriorates with each successive generation, and goes down to speedy extinction. It is the robust, sturdy, clear-headed, strong-handed toiler of to-day, whose sons and daughters will inhabit homes of wealth and occupy positions of responsibility a few years hence.

The effects of unfavorable heredity may be manifested in various ways. In the first place, the child may be born with the disease already developed. Examples of this class may be seen in hypertrophies, atrophies, and inflammations of various organs; in exudations, as hydrocephalus; in infantile syphilis; in new growths, such as nævus, tumors, and certain forms of cancer; in the pre-natal deposition of tubercles, parasites, and some inorganic products; in arrests of development, such as cleft-palate, hare-lip, spina bifida, and that defective closure of the heart which produces cyanosis; and in those unusual developments known as monstrosities. Secondly, the disease may be transmitted, although its manifestations are not developed at birth. This may be the case with some of the diseases already mentioned as also occurring in the first class, as well as with many others. Examples are seen in scrofula, cancer, consumption, epilepsy, rheumatism, gout, insanity, and the "specific" disease. Again, there may be no actual disease, but only a tendency to disease, in the shape of an inherited weakness of some special organ or in some particular direction. These tendencies render their possessors unduly liable to suffer from particular diseases, but do not make it necessary that they should do so, provided that their environment is favorable. Lastly, the faulty heredity may be manifest only in a general weakness of the whole system, a lack of vigor and vitality, which renders its possessor an easy victim to whatever malady may attack him. This is the cause of many of the deaths which are registered under the heads of infantile debility, diarrhœa, brain-disease, and other common affections of infancy.

To the actual diseases, special weaknesses, and unsound constitutions resulting from unfavorable heredity, add now the environment of *poverty*, with its usual accompaniments of ignorance, carelessness, and inefficiency on the part of the parents, resulting for both parents and children in privation of food, clothing, shel-

ter, and fuel, and we begin to have some faint conception of the perils which surround infant-life in a large proportion of cases. Without adequate nourishment, and improperly cared for in every respect, life is one sharp struggle with want, and it is little wonder that want often gains the victory. In England, for the ten years ending with 1875, an average of eighty-two deaths annually was assigned to starvation alone. But privation and destitution exercise a controlling influence over the mortality of infancy under other names than this. What the form of death shall be is determined by various circumstances. It occurs largely from the diseases of denutrition and debility, rickets, scrofula, consumption, and other constitutional diseases.

Exposure to *cold and wet*, especially in the sharp vicissitudes of our winter climate, and more particularly when this is added to the causes already named, results in a largely increased prevalence of the acute lung-diseases. These are extremely fatal even in adults, and the mortality is proportionately large in children. Says Routh, in his work on "Infant Feeding": "Among the most pernicious influences among young children we may include cold. It is a household word among us, which takes its origin from the Registrar-General's returns, that a very cold week always increases the mortality of the very young and the very aged." The same statement is true in America, though it may be in a somewhat less degree, owing to the fact that our houses are better provided against extreme cold than are those of the English. Throughout England, one sixth of all deaths from lung-diseases occur under five. In London, forty-four per cent of the deaths from pneumonia and bronchitis take place under that age. In Massachusetts, the proportion of deaths from pneumonia under five is thirty-four per cent. These deaths occur largely in the inclement portions of the year. In England, both bronchitis and pneumonia attain their maximum in the first quarter of the year, decline during the second quarter, reach their minimum during the third, and begin to increase during the fourth. In Michigan, Dr. H. B. Baker has shown that the greatest prevalence of the acute lung-diseases is in February, and the least in August. In Massachusetts, March has the largest number of deaths, and August the least.

Four distinct but closely related causes combine to produce the diarrhœal diseases, which result in one fourth of the entire mortality under five. These are heat, improper feeding, filth, and overcrowding. The influence of *heat* is seen in the facts that, in our climate, the overwhelming majority of cases in these diseases occur during the hottest months of the year; that their prevalence is greater in the southern portions of the temperate zone than in the northern, and in unusually hot summers than in those whose

average temperature is less; and, in general, that the number of deaths from these causes is directly proportional to the elevation of temperature, especially if it be long continued. Thus, of 3,216 deaths from the diarrhœal diseases in Vermont, New Hampshire, Massachusetts, Rhode Island, and Connecticut in 1883, 2,745, or eighty-five per cent, occurred during the months of July, August, and September. The same States showed an increased mortality from these causes during the unusually hot summers of 1880 and 1882. In the city of Boston, for the nine years from 1867 to 1875 inclusive, the mean temperature of the months of July and August varied from 68·6° in 1874 to 72·3° in 1870, and averaged 70·5°. The highest death-rate was in 1872, when the mean for the two months was 71·9°, and for the hottest single month was 73·1°; and the lowest was in 1867, with a mean for the two months of 69·8°, and for the hottest month of 70·4°. In New York, during the month of July, 1872, the mean temperature was 79·57°, or 3·43° higher than the average for the ten previous years. As a result, the mortality for the quarter was the highest ever known in the city, and that notwithstanding that the other two months were not unusually hot.

It must be stated that, fatal as is the effect of heat upon children under five, the proportionate mortality is still greater when the investigation is limited to infants under one year of age. Dr. Blackader says that a very hot summer month will triple or even quadruple the mortality of infants under one year, though that of children from one to five is barely doubled. During the year 1872, in New York, nearly sixty per cent of all deaths were under one year of age, and more than forty per cent took place in the summer quarter.

The effects of *improper feeding* are seen in the fact that, whether in city or country, in hot summers or cool, only a very small proportion of deaths from infantile diarrhœa occur among infants who are properly nursed upon the milk of a healthy mother—which must be considered the only natural and proper method of feeding young infants.

Sir Hans Sloane showed years ago that the mortality of those properly nursed upon breast-milk was to that of those who were bottle-fed as 19·2 to 53·9 per cent. Dr. J. Wilmarth reports that in a country practice in Massachusetts, out of one hundred and one children nursed wholly, or nursed and fed with nursing after a few months to weaning-time, and who were under his observation for a series of years, there were twelve deaths from various causes, none of them from cholera infantum; while among nineteen children artificially fed, there were during the same time eight deaths, six of them from cholera infantum. Says Messener: "Cholera infantum attacks only those children who have been

raised without breast-milk, those who have been weaned too early or too hastily, or those to whom, on account of the failure of the mother's milk, other foods have been injudiciously administered. Under other circumstances than these, children enjoy a complete immunity."

The artificial feeding of infants often results from physical inability on the part of the mother to nurse them, and this inability in turn is the result of defective heredity. "The mother makes the child," and the mother's weakness ofttimes results in the death of the child, or even of the children's children.

When we turn to consider the merits of the different forms of artificial feeding, we realize the intimate relation of improper feeding to the next cause, namely, *filth*. Cow's milk, the most common and generally advisable substitute for mother's milk, when exposed to the air at a summer temperature, soon ferments and develops a peculiar poison known as *tyrotoxicon*, which is a most potent factor in the causation of cholera infantum. It is also, says Prof. Lister, "a pabulum for all kinds of organisms; nearly all varieties of bacteria will live in it." In addition to this, it often absorbs and becomes the carrier of various other forms of filth, both organic and inorganic, all of which either directly or indirectly increase the tendency to disease. These evil results may be avoided, in a large measure at least, by the modern process of sterilization of milk, whereby existing germs are destroyed, air excluded, and fermentation prevented.

But filth may be introduced in other ways than in milk or food of any kind; and, however introduced, its effects are always disastrous. Says Mr. Simon: "Nothing in medicine is more certain than the general meaning of high diarrhœal rates. The mucous membrane of the intestinal canal is the excreting surface to which nature directs all the accidental putridities which enter us. Whether they have been breathed, or drunk, or eaten, it is there that they settle and act. As wine gets into the head, so these agents get into the blood. There, as their universal result, they tend to produce diarrhœa."

In August, 1883, the health-officer of New Haven, Conn., in a paper entitled "A Practical Argument for Sewers," reported the following, which well illustrates the evil effects of impure air: "There were forty-three deaths in New Haven from infantile diarrhœa in July. The forty-three deaths occurred in thirty-two different streets and in thirty-eight different houses. But the most remarkable fact is that thirty-four of the forty-three victims were living upon streets in which there is no public sewer, and in houses about which are still tolerated those beastly abominations called cess-pools and privy-vaults. In most of the nine cases where the houses had sewer connections, they were only for kitchen and

laundry purposes, and the stinking vault still maintains its position in the back yard. Observe this fact also: a considerable majority of the population of New Haven resides upon the sewered streets, and yet only nine out of forty-three deaths from a disease which is chiefly caused by foul air occur among the majority; while thirty-four of the forty-three are among the minority, who reside in dwellings surrounded by the fragrant companionship of time-honored filth-pits. Any person can draw intelligent inference from the above plain facts."

The remaining important factor in the production of infantile diarrhœa is *overcrowding*. This, indeed, is but the occasion of one of the most dangerous forms of filth, in the shape of air deprived of its vitalizing qualities, and charged with impurities derived from the breath and bodies of men and animals, which is sometimes known as "crowd-poison." "It is this air," says Dr. Richardson, "in our overcrowded towns and cities, where there is no vegetation to revivify it, which we distinguish as something so different from the fresh country air that streams over meadow and forest. It is the breathing of this air that makes the child of the town so pale and lax and feeble, as compared with the child of the country. It is this air that renders the atmosphere of the crowded hospital so deficient in sustaining power. It is this air that gives to many of our public institutions, in which large masses of our poorer, ill-clad, uncleansed masses are herded together, that 'poor-smell,' as it is called, which is so depressing both to the senses and to the animal power."

Cholera infantum is well known to be almost exclusively a disease of cities, and absolutely so in its epidemic form. The city of Manchester, N. H., contains only about one tenth of the population of the State, yet in 1883 it furnished nearly one half of the whole number of deaths from this disease; while in 1885, the three cities of Dover, Portsmouth, and Manchester, together containing less than one sixth of the whole population, reported considerably more than one half of the entire mortality from cholera infantum. The State of Massachusetts contains eighteen cities and towns of more than fifteen thousand inhabitants, while Vermont has none. The mortality from cholera infantum in 1883 was 3·49 per 10,000 in Vermont, and 9·53 per 10,000 in Massachusetts.

According to Dr. Farr, the mortality of districts increases with the density of their population; not, however, in the direct proportion of their densities, but as the sixth root of their densities. But while the total mortality increases in this proportion, the mortality under five increases in a much greater ratio. Thus, with a density of 166 to a square mile, the death-rate at all ages is 16·94 per 1,000, while of those under five it is 37·8 per 1,000. This ratio increases gradually and with considerable regularity

with the density of the population in the districts considered, until with a population of 65,823 to a square mile, the death-rate for all ages reaches 38·67 per 1,000, and for those under five, 139·52 per 1,000—that is, while the total death-rate is increased a little more than twofold, that under five was nearly quadrupled.

Another fruitful cause of death, and one which especially helps to swell the mortality of infancy, is *contagion*, including in that term all those influences by which disease is communicated from one individual to another, either by direct contact or through the atmosphere. This is the prime cause of the large class of zymotic or germ diseases, which in their various forms carry off nearly one third of all children dying under the age of five years. In general terms it may be stated that, while contagion is the direct cause of these diseases, yet their prevalence and fatality are in inverse proportion to the general observance of the laws of public sanitation and private hygiene.

The depressing influences of extreme poverty, filth in all its forms, and the overcrowding of large cities, are great promoters of contagion, resulting in epidemics, plagues, and pestilences; while strict cleanliness, fresh air, pure water, and hygienic living, tend greatly to restrict its spread and prevent these results. Temperature, also, has much to do with the prevalence of zymotic diseases, some of which require a certain high degree of average temperature, while others thrive best in cold weather. Extreme degrees of heat and cold (boiling and freezing) destroy the life of most germs, but not of all. Thus, the first sharp frosts of autumn cut short the progress of yellow fever, while diphtheria is somewhat more prevalent in winter than in summer. The strict isolation of the sick, and careful disinfection of their surroundings, are also essential to the limitation or prevention of contagious diseases.

The death-rate among infants and young children is especially influenced by the five principal acute contagious or infectious diseases—namely, measles, scarlet fever, small-pox, diphtheria, and whooping-cough. According to English life-tables, these five diseases were the cause of 18·8 per cent of the entire mortality under five for the ten years from 1860 to 1870, while the average age of all persons dying from whooping-cough was 1·8 years, from measles 2·7 years, from diphtheria and scarlet fever 5·8 years, and from small-pox 11·9 years.

This latter disease, which was formerly by far the most fatal of the class, has of late years been shorn of its terrors by the beneficent discovery of Jenner. Thus, during the sixteenth and seventeenth centuries, it is estimated that from seven to twelve per cent of all deaths were caused by small-pox; while since the gen-

eral introduction of vaccination the proportion has been reduced to less than one per cent.

The next most dreaded and at present the most fatal of these diseases is scarlet fever. In England, during the period already named, 6·7 per cent of all deaths under five were due to this cause; while an analysis of the registration reports of Massachusetts shows that two thirds of the deaths from this cause occur under five years of age.

Diphtheria is especially a filth-disease as well as a contagious disease; while the prevalence of each member of the class varies greatly in different localities and different years, being largely dependent upon certain unknown epidemic influences, which as yet have not been brought under the control of man.

THE ORIGIN OF FOREST-GROUPINGS.

By the MARQUIS DE SAPORTA.

THE organic relations or homologies of structure, showing connections of different beings with one another, which, in ignorance of their real bearing, were formerly made useful only for the classification of animals and plants into natural groups, have acquired a new significance since the doctrine of evolution has been brought to bear upon questions of origin and of the progress through time and space of living beings and their relations with those beings whose former existence is revealed by paleontology. The question whether there are evidences of affiliation of the former by the latter, of a direct relationship, has received attention from students; and, as one of the attempts to solve it, we may mention M. Gaudry's essay on "The Links in the Animal World," in which the development of the mammalia through geological times is investigated on the basis of the osseous frame. A difficulty that has never been surmounted besetting the study of the terrestrial mammalia with aërial respiration, arises out of their power of changing their place, which, while it is limited by geographical restrictions in the case of quadrupeds, is complete with birds. It is easy to conceive that overlappings and general irregularities have time and again been introduced into the combinations of groups of animals which any given country has successively contained. By that fact alone, the new-comers of each period, at points where we have not been able to observe their ancestors in the country of their origin, have an air of having risen suddenly and been preceded by nothing.

This is not so much the case in the vegetable kingdom, and is least so with its most eminent representative, the tree, particularly the forest tree or the tree that has become social. It is true that

while we sometimes possess of fossil animals entire skeletons, and nearly always parts on which we can justly base a classification, we ordinarily get of the ancient trees only isolated specimens of leaves, or more rarely of fruits and seeds. We, nevertheless, generally succeed in determining these relics, and, by comparing them with analogous living ones, in forming conclusions, the probability of which carries conviction. Thus, with the aid of the data furnished by stratigraphy, we can not only reconstitute the forests of former days, but can also arrange them chronologically, grasp their mutual relations, establish their filiations, and finally explain how they have in the past been displaced and renewed.

It is necessary to take account of the peculiarity that trees are enrooted or fixed in the soil, so that only their seeds can leave them and be carried away, but never to a very great distance. This fixity is certainly one of the causes of the regularity and relative slowness of the modifications to which arborescent vegetation has been subjected in the periods anterior to ours. The new-comers of each region can never have rapidly traversed distances. It has been rather by slow steps, and by the aid of at first partial introductions, that the flora of all the epochs has been transformed. Instead of leaps, we meet with modifications aided by time, which were worked out through a long duration before becoming definitive. An attentive examination of the vegetable impressions collected over many successive levels and at points distributed along the course formerly followed by the vegetation, and marking its advance, should therefore enable us to recover the partial terms of the presumed filiation of the types whose origin we are investigating.

One phenomenon has been remarked in intimate relation with this gradual and successive substitution of plants; it is the cooling of the globe, operating insensibly, but subject to a general movement, the progress of which, although extremely slow, has never been arrested. Plants have pursued their migrations under the rule of this phenomenon, moving toward the south and gradually abandoning the north, beginning with the extreme north, or the immediate environs of the pole. The discovery of numerous vegetable fossils at different points in the arctic regions, in Spitzbergen, Greenland, Grinnell Land, etc., has been sufficient to give rise to terms of comparison and demonstrate what was the character of fossil vegetation when that of Europe more or less resembled the present vegetation of countries near the tropics. Hence it has been possible to establish with fair probability not only the general march but also the filiation of a number of plants; and it has been ascertained that the direct ancestors of part of our trees originally inhabited the interior of the polar circle, while many others, confined now to southern countries, once had European

predecessors. "The forest" may be defined as an association of trees freely grouped over a space; or, as the vegetable kingdom delivered to its own forces and meeting conditions favorable to its becoming master of the soil and spreading its wealth over it. The "virgin" forest is the forest into which man has penetrated only in passing, or upon which he has never laid hand to attack or modify it. It is peculiarly the forest of hot countries, or of the intertropical zone, where everything concurs to stimulate luxuriance of the vegetable kingdom. Even in temperate climates, whose pretensions of this kind are modest, we have only to transport ourselves into some region where the native forest yet exists in all its primitive grandeur, to perceive at once the might and majesty of the vegetable kingdom thus abandoned to itself, and having uncontested possession of the territory. Forestal associations interpret the influence of the climate to which they are adapted. They change in aspect and composition according to the latitude, and present characteristic diversities combined in a determined and successive order as we advance from the neighborhood of the polar circle toward the south. In the review which we can make of them, they constantly present a double aspect, as they may be considered in themselves, or as with reference to their relations with the past, and their bonds of kindred with anterior vegetations. But, previous to placing ourselves at the latter point of view, we should glance at existing plants to determine the features of the order which now presides over their distribution.

The domain of the forest extends beyond the polar circle in Europe and Siberia, where it reaches and even passes a little above the seventieth degree. In America it retreats from that region about Labrador and Hudson Bay, the polar circle being hardly indented in the interval between Mackenzie River and Bering Strait. But in this domain, as in those that succeed it, an essential distinction should be made between the resinous forests, consisting almost exclusively of conifers, and those that are composed of "foliage-trees." In the north, the forests of resinous trees extend over great spaces. In central or more southerly regions, these forests prefer the mountainous masses. Besides the conifers, many foliage-trees—among them the birches, alders, aspens, willows, and mountain-ash—penetrate within the polar circle, and constitute a part of the arctic forests. South of the sixtieth degree in Europe, and of a lower latitude in America, there extends a richer assemblage of varieties, but insensibly connected with the preceding one. The birch, oak, elm, maples, ashes, and limes are its characteristic trees, while the foliage-trees and conifers of the preceding group are not excluded from it. The latter show a tendency to graduate themselves on the slopes as they ascend them, much as, in going from southern to northern coun-

tries, we pass through regions occupied by like series of vegetation. Pursuing our course from north to south, we find the beech giving place in lower latitudes to varieties of oak; and it is one of the effects of this movement that other oaks appear at first in scattered colonies, as does also the chestnut, which, aside from its requirements as to the composition of the soil, seems to find, especially in southern Europe, the conditions normal to its forest development. The association of foliage-trees, whose outline is thus sketched, which would cover central Europe with a continuous forest if the continent had not been taken possession of by cultivation, is found on the southern slopes of the great mountain-ranges, only under specially favorable conditions of altitude and moisture. Its principal characteristics, besides the particular grouping of species, result from the winter caducity of the leaves, to the law of which the holly, the box, and the ivy—types also belonging to the next southern or Mediterranean group—are almost the only exceptions.

The Mediterranean group touches abruptly on the preceding one, and derives its name from the Mediterranean Sea, of which it occupies the whole periphery. In all the regions within this perimeter a similar forest flora covers with the same species a soil generally hilly, under a climate dry and warm, while subject to violent contrasts. The evergreen oaks, other oaks with semi-persistent foliage, the laurel, olive, pomegranate, terebinths, some of the maples, the oleander, and the carob; numerous shrubs with persistent leaves—laurestinuses, arbutuses, mock-privets, daphnes, heaths, cistuses, etc.—contribute to the constitution of this assemblage, which is all the more striking because an astonishing richness of characteristic details is concealed in it under an apparent uniformity. A more careful examination of the elements of which this flora is composed is demanded if we undertake to seek their origin. Besides the foliage-trees, the group includes conifers which are peculiar to it. The pines alone cover a large extent, one of them, the Aleppo pine, being very generally diffused, while a number of other species have each their determined station and place. The mountains in the interior of the region bear species that are special to them, and it is to such scattered islands of vegetation that we are indebted for such choice garden-plants as the spruces of Andalusia, Numidia, Mount Parnassus, Cephalonia, and Cilicia. In the same category are the cedars, which, with different names and varietal distinctions, people the ridges above a certain level of altitude of the Taurus, Lebanon, and Atlas. These are the mountaineer conifers, adapted to the Alpine stations of the Mediterranean region, where the altitude permits the beech, chestnut, maples, lindens, and birch to reappear and maintain themselves here and there in sporadic colonies.

Another distinct grouping of species in the bosom of this region is dependent on the nature of the soil. It includes the cork-oak, the chestnut, and the maritime pine, which are limited to the siliceous zone, and with them a whole train of plants and shrubs which are found with striking uniformity wherever the mineral composition of the soil is of similar character. So strict an adaptation, so absolute a selection, could not have been the work of a small number of centuries, but they may properly be attributed to causes that existed in a remote past.

To complete our review of the Mediterranean forest-grouping, we should consider, besides the dominant forms, some exceptionally sheltered parts of the regions, and other regions in which intermittent rigors of temperature have spared only the hardiest types. Three elements may be distinguished in the aggregate of about two hundred species included in the forestal vegetation of this region: First, the principal and characteristic element, in which plants with persistent leaves predominate, and which includes among its rarer types species in a declining condition, which are cantoned upon the best-sheltered or most southern points, and are transitional toward tropical types; next, the mountaineer element, to which altitude is favorable; and a third element, to which heat and moisture are agreeable. The last includes plants with deciduous leaves, which, while they can accommodate themselves to a cold climate, are better adapted to southern temperatures, and do not grow spontaneously in the central region; with which corresponds a group of trees—large, not very numerous, and usually monotypal—which deserves attention because of what it has been in the past, and which may be said to represent the southern prolongation of the central group, elbowing into the Mediterranean region. Its members, including the alder, the Eastern witch-elm, the hornbeam, the plane, the liquidambar, the fig, vine, some ashes, lindens, and walnut, are more in contrast with the mass of the Mediterranean plants than with the types equivalent in order that are domiciled farther north. It might be said of them that, while they are found associated with the former plants, they belong naturally to the category of the latter, as they would visibly had not the free extension of these to the southward been arrested. This view is confirmed by the examination of the forestal flora of a corresponding latitude in America. The absence on that continent of any vegetable domain equivalent to that of the Mediterranean disengages that element, and supplies, through the plane, the liquidambar, the persimmon, and American vines and walnuts direct from the ancient world, a parallelism or a repetition of forms which the study of paleontology helps to illustrate.

The principal elements of the Mediterranean group—hollies,

laurels, olives, myrtles, etc.—with their narrow, elongated, coriaceous, entire or spiny foliage, only slightly divided, do not display the luxuriant fullness of tropical forms, but seem to lead toward them. They touch upon them on some sides, indicating the influence of a special medium, determined by conditions of intermittent heat and dryness. A peculiar feature of the Mediterranean group, and one which may help to determine its significance, is the capricious and uneven distribution in the interior region of plants of the most decided characteristics, evidently outside of the range of common species, manifesting affinities with hot country types. These species are narrowly cantoned in certain stations. The *Pinus excelsa* of the Himalayas is found only on a single mountain of Macedonia; the Algerine *Thuya* only in the Atlas; the false cork-oak in only a few specimens at a single spot; the carob at a few places on the littoral; the poplar of the Euphrates on the banks of the Jordan and at one point in the province of Constantine. Numerous instances of this kind betoken the existence of a former condition which has been more or less changed by subsequent events, that the group has suffered from revolutions which have displaced and partly eliminated elements that were formerly more widely distributed. The group has been impoverished, probably by the depreciation of some elements, certainly by the destruction of others.

This brief review of the forestal zones from north to south is sufficient for the study we have in view of the paleontological origin of the principal types of trees. This origin, which is at the best hard to determine, could not be sought with any probability, except as to those species concerning which we have data of a character to cast light on their history in the past, their former migrations, and their career through time as well as through space. Europe, North America, and the arctic zone furnish these data. They are not to be found in India, China, and Australia, for the guiding thread would be wanting there. Knowledge of many fossils is not enough of itself to conduct to the desired end. Vegetable impressions are useful indications, which, taken singly, have a relative value, but rarely lead to results of a material bearing.

Multiplied observations and discoveries, and fossil beds of unusual richness, to be explored at many points from north to south, have been required to give a view of the floral past of a part of the globe. It was also necessary that these beds, instead of belonging to a single period, should be frequently separated by long intervals distributed through successive ages, so as to present the complete picture of the series of past times. Thus a comprehensive grasp has become possible of the vicissitudes through which the vegetable kingdom has gradually undergone transformation.

Changes insensible at each single step have in the long run resulted in modifications of the aspect of the landscape and replacements of the types and species composing the floral carpet at a given movement by forms different from them, and also from those before which they were themselves destined to retire at a later period.

The impression which one feels in the midst of a deep forest is one of perennial duration. Except man, what is there to uproot those giants that have lived through centuries? What action can be conceived of that will exclude them from the ground which they possess so completely? The first impression would almost make these forest masses coeval with the globe, its natural product and spontaneous dress from the days of its youth. Such an impression would be a mistaken one. The forests have not been perpetuated in the same order from the beginning, but have changed much in the course of ages. Those which we now see have taken the place of other more ancient ones, and these substitutions have occurred many times, sometimes through partial modifications and sometimes also under such conditions that the old order has only indirect relations with the present one, or is even wholly foreign to it.

Since a serious mind can not suppose that at every revolution of plant-life there has been a total destruction of the anterior elements, followed by a creation conceived anew in all its details, we are forced to seek in the order which precedes the reason for the existence of that which has replaced it. This view implies an endless chain of causes and effects, of ancestral and derived forms, stretching along, now spreading, now continuing themselves, to spread out again, and—in what more particularly concerns the types of the vegetable kingdom—emigrating in a determined direction. This direction is found to have consisted, for plants, in a march from north to south in search of more favorable regions and stations better fitted to the exigencies of acquired adaptation, as rapidly as the terrestrial temperature declined from its pristine conditions, as latitudes took on their individual characteristics, and as the arctic zone, which had been temperate, grew cooler and became more and more differentiated. The polar circle was thus constituted a barrier that became more pronounced, less accessible, and was finally closed to arboreal vegetation, while under the operation of the same movement the present temperate zone became cooled in an equivalent measure, was impoverished, and gradually stripped of a considerable part of its floral wealth. The remnants that escaped this elimination in those successive and numerous retreats that filled the second half of the Tertiary period still occur, scattered and dwarfed, in the southern part of that zone, and upon points where the less sensible depression of

temperature has permitted them to maintain themselves sporadically.

By regarding these considerations and this presumed march, we succeed in determining the connection between recent and fossil species, and evidences of affiliation between them. There also exist relations not to be neglected between some recent types and other old ones which we can not believe to be wholly lost, and others between present forestal groupings taken separately and those which have succeeded one another through the ages; but the further we go back, the more we address ourselves to a distant order of things, the less tangible are these relations found to be. Of all the Carboniferous vegetation there remain only isolated or dwarfed types, as of *Equisetæ*, ferns, and club-mosses. The singular Japanese gingko, and perhaps the dammara of the Indian Archipelago, can trace their ancestry back to that period. A greater number of estrays have survived from the Secondary ages; but they are still rare—auracarias, cedars, pines, thuyas, and a few colonies of cycads south of the equator. There has been something vague and undetermined about the "foliage" trees since they first appeared in the Cretaceous period; but their evolution and characteristic physiognomy have been tending to fix themselves. The magnolia, tulip-tree, plane-tree, ivy, etc., have hardly varied since then; but the subsequent modifications of other European flora have been so frequent and profound that no collection of existing species corresponds except by partial traits that have been questioned with the Cretaceous vegetation. The correspondence is somewhat closer with the vegetation of the Eocene, especially of the later Eocene. The examination of certain floras which are referred to this horizon has shown that vegetation has not varied much since then, except from the impoverishment which it has suffered by the subsequent elimination of some types, and the addition of a number of deciduous types of later introduction. Thus, a considerable proportion of forms, the ancestors of which appeared in the Eocene, have persisted in place from that epoch, while those which have since migrated are found in more southerly regions.

It is in the Miocene, particularly in the later Miocene, that the relations become manifest of the deciduous trees of southern habit which we have spoken of as being dispersed over various points of the Mediterranean domain—the plane-tree, the liquidambar, the planera, the linden, the vine, some hornbeams and ashes, the date-palm, the pomegranate, etc.; and the lauriferous grouping of the Canary Islands, preserved intact by means of its insular situation and of the persistency of local climatological conditions, reproduces unchanged the picture of a mountain-forest of central Europe, as recent discoveries have shown it to have been in the

later Miocene and earlier Pliocene. There are the same species, the same mixture of laurels, hollies, olives, to which are added recent Japanese or Caucasian forms of nuts, maples, elms, and toward the high summits pines and firs very like those of the higher mountains of Teneriffe, Morocco, and Asia Minor. Collections made by M. Marion in the marly sediments of Durfort, where bones of the southern elephant were also found, and in the tufas of Valentine, near Marseilles, show that a number of plants now found only further south, still in the second half of the Pliocene inhabited the hills and shore-lines of southern France. These plants were then, therefore, at home further north than they are now found; and their occurrence in the Pliocene points to a later flowing back of species, amounting to a definite retreat in the Quaternary age.

This retreat, perfectly logical and almost regular in its operation, is connected with changes of climate, which were themselves in relation with a progressive depression of the temperature of the earth. It is connected also, in a parallel order of phenomena, with the exhaustion of some races, and with the development, by a concomitant origination, of other young and new races, favored by the same circumstances that caused the elimination of the races that gave way to them. Considering all the elements of the question, we find that it is by the extension, at a given moment, of vegetable races previously localized and realizing a certain amount of variation, that species are constituted at the start. Once characterized—that is, after the acquisition of a total of characteristics, at first fleeting, then hereditarily fixed—the species is permanent nevertheless only in a relative fashion so long as there exist in it parts susceptible of differentiation anew. The amplitude of the limits between which it may range through the course of time depends on the proportion of the elements that remain variable to those that will not change. The morphological oscillations of which it offers an example are thus determined by its own tendencies to submit more or less readily to excitations from without. Hence there are evident inequalities in the specific type, sometimes running to obscure shades, sometimes clearly cut; the last especially after the exclusion of intermediate forms.

There exist, in fact, fleeting species, which can not be circumscribed by any precise limit; and others, fixed in their minutest traits, that are susceptible only of insignificant variations. The forms of the latter category, such, for example, as the sequoias of America and the cedars of the Atlas, persist in the places of which they have once taken possession, where some of them have been driven back and cantoned, so that quite contrary conditions or the intrusion of more vigorous forms have not sufficed wholly

to exclude them. We see, from this manner of looking at things, that the relations of the present arborescent species with those of ancient ages are only the last consequence of a march or an antagonism of long continuance, which must of necessity have left traces. Regarding this closely, we find the indices of filiation of the living by fossil species not wanting, but fully confirming our interpretation; and the genetic bonds disclose themselves to the investigator from the moment when he consents to regard the species as having acquired by degrees the characteristics which it possesses, and also as susceptible of displacement by extension or by crowding back.

The morphological connection has certainly the signification of a relationship; but it can and must vary according as the relationship is more intimate or remote, direct and immediate, or indirect and collateral. We can, by the aid of a direct method, rather led by a kind of intuition than subjected to precise rules, found a judgment concerning the bearing of these analogical shades. While the opportunities of observing forms nearly allied to those that are familiar to us diminish as we go back in the past, yet, at whatever age we place ourselves, a near resemblance always induces the notion of a direct descent of the recent form from the one which predicted its traits in the midst of an order of things remote from that which has since prevailed. The observed resemblance may also be conceived to be the more decisive as the species in which it appears belongs to a more ancient period. The indices of genetic connection may thus go far back into the past, and as to certain types of trees little subject to variance, they are discerned in a quite remote past. In order logically to reach precise conclusions, he who engages in such researches should take account not only of the type, but also of the species considered in itself, that is, of the state of race, with its particular history, of which it is sometimes possible to follow the incidents. So far as is possible, the type, or union of allied forms, derived originally from the same stock, should not be confounded with the species, or the particularized race, which, its characteristics having been once acquired and its aptitudes determined, necessarily assumes a march in harmony with the tendencies that distinguish it, within an area suited to it. The plane-trees, poplars, tulip-trees, beeches, and chestnuts appear toward the middle of the Cretaceous period, but it does not follow that existing forms are the immediate descendants of these primitive forms, or of any one of them taken separately. The traces of our plane-trees, the visible ancestor of the tulip-tree, and the evident predecessors of existing poplars, make their first distinct appearance during the Tertiary. So do those of the beech and chestnut, the introduction of which into Europe took place through isolated individu-

als, distinguished by shades which were gradually effaced on approaching modern times.

The principal requisite for tracing the presumed origins, whether of the type at its birth, of supposed ancestors, or of the direct antecedents of existing species, is to have in mind the exact succession of the periods and stages, giving the relative date of each of the determined first appearances and the order of the constitutive elements of the march which the forms of which we meet the traces have followed through time and space. The succession of ages, represented by beds deposited in a constant order, or stratigraphic geology, makes this known to us. It is also necessary to take account of the changes that have been impressed upon the whole vegetable kingdom during this long series of periods. The changes have been too profound, and attended by too complete renovations, for us to be able to find the cradles of existing plants in the primitive periods.

Three great plant-periods may be distinguished, starting from the moment when the surface of the globe first began to be covered with aërial vegetation: the primary or paleophytic period, or cryptogamic era, which derives its name from the domination of cryptogams; the secondary period, or mesophytic, during which gymnosperms—conifers and cycads—obtained the predominance, while foliage-trees were still absent; and the tertiary or neophytic period, also called angiospermic, from the presence of the higher plants and particularly of the foliage-trees.

The last of these periods, which began with the chalk and is still in continuance, is characterized by the appearance and extension of the higher plants, and was also coincident with the first signs of polar refrigeration and with the more and more marked decrease of terrestrial temperature with increase of latitude. This fact, at first hardly sensible, then gradually accented, exercised an influence within the polar circle before extending its action beyond, into the temperate zone, which was for a long time hot, and afterward warm, while the regions around the pole were already frozen. A remarkable relation certainly seems to exist between the beginning and the course of the climatological depression of the northern regions and the progress of vegetation, which perfected itself in a parallel line. Indeed, it closed the entire cycle of its definitive evolution by the adjunction of the angiosperms, the most perfect plants; and these acquired preponderance as rapidly as the cooling of the arctic regions went on. These regions appear to have been exempt till this time from the rigors of a cold season, and, by that fact, subtracted from the effects of the winter rest.

It is certain that the vegetable kingdom, as soon as it had acquired all the elements of which it is still composed, began to dis-

tribute itself in groups ordered according to the latitude; and this movement once started, the differences between the groups became continually more accentuated by the increasing exclusion in each of them of a part of the types which they originally contained. There resulted from this a constant impoverishment of northern countries as compared with southern ones, which gained, at least by contrast, what the former never ceased to lose. The movement has thus tended to a differentiation by zones, and has resulted in despoiling them, but in unequal proportions, increasingly as they are removed from the tropical zone, the only one which has been exempt from the spoliation.

Let us not forget that, parallel with this movement, working, moreover, with an extreme slowness and in harmony with it, another movement, purely organic and evolutionary, although incited, if not directed, by the former, has not ceased to push to development and to morphological differentiation various groups of plants; particularly of those which, relatively young and plastic, were susceptible, by this fact, of giving birth to new forms, and, by successive splittings, to new types. These are the angiosperms, which, having once gained preponderance, have offered the spectacle of an increasing multiplicity of races and forms. That multiplicity could only increase. The displacements resulting from the climatic depressions have aided in it by inducing changes of stations and opening new cantonments to races not yet fully established. The revolutions of the surface, continental contiguities, and the more or less accentuated orographic relief, have constituted other factors not less active in the general push of species, incessantly solicited to vary as they adapted themselves to the soil of the regions into which they penetrated, as they scattered, and as they struggled victoriously against rival species.

Such is the spectacle which the vegetation of the globe has not ceased to present; and the existing forests appear as the final resultant and ultimate consequence of that long series of alternatives which is summarized in the expression, "the struggle for existence."—*Translated for the Popular Science Monthly from the Revue des Deux Mondes.*

The development of a new vegetation on Krakatoa is affording a rare opportunity for studying the origin of floras. The old vegetation was totally destroyed, with all its seeds, by the great heat that prevailed during the eruption, and the island was covered with a thick layer of cinders and pumice-stone. But in June, 1886, a new growth, of ferns and isolated plants of phanerogams, had appeared on the shore and the mountain. The riddle of its appearance in a soil apparently so unpromising was explained, on examination, by finding that the mineral had received a coating of fresh-water algæ, which gave it a gelatinous and hydroscopic quality, by virtue of which a higher vegetation could gain a standing. The phanerogamic plants are similar to those which take possession of newly-raised coral islands.

CHINESE MARRIAGE CUSTOMS.

By ADELE M. FIELDE.

SEXUAL selection, which has doubtless greatly influenced the development and advancement of certain races, has been inoperative in China during many centuries, because, under the prevailing usages, the contracting parties have, before espousal, no opportunity to judge of the strength, beauty, or intelligence of their consorts. Romantic love has no part in marriage or its issue. This may be one of the causes of China's arrested civilization, and of the astonishing fact that her astute people have invented nothing and discovered nothing during hundreds of years.

Although polygamy is legal, it is practically so expensive and inconvenient as to be uncommon among the masses. Under the law, no man may have more than one wife, though he may add to his household any number of helpmeets. The wife, brought home with unique ceremony, may under no circumstances be superseded in her well-defined sphere, the penalty of an attempt to put an inferior in her place being a hundred blows. In all cases the marriage engagement is made by the senior members of the families concerned, and is usually made without the knowledge of the future husband or wife.

Marriage being essential to the continuance of the line of worshipers before the lares and penates, a man who will not marry is reckoned guilty of filial impiety. Spinsters are unknown and bachelors are few. The universal and intense desire for posterity in the male line of descent leads to much self-sacrifice on the part of parents, in order to secure wives for sons, and causes them to make provident arrangements for their marriage at an early age. Betrothals of expected infants, conditional upon their being of different sexes, are not rare. Among the poor it is not uncommon for a newly-born daughter to be given away, that a girl of another clan may be taken by the mother, reared at her breast, and bestowed upon her son in after-years. In many families there is at least one little daughter-in-law that is being brought up in the house of her future husband.

Parents of moderate means endeavor to provide wives for their sons by the time they are twenty years old, while but few keep a daughter after she is sixteen. Those who have a marriageable son, and the means of meeting the expense of taking a daughter-in-law, place their case in the hands of an old female friend or of a matrimonial agent, called a go-between, who finds among her acquaintances that which is required by her client. The parents of the two young people do not meet for conference, and are not usually known to each other even by name. The negotiation is

conducted by the go-between, who is the sole medium of communication between the two families. When all details have been settled, a sum of money is carried from the parents of the groom to those of the bride, and the betrothal is completed. This pact can under no circumstances be legally broken by either party. Even the discovery of fraud on the part of the agent does not vitiate the contract.

When the bride knows that she is to be married, she must evince by word and manner the deepest melancholy, and she gains commendation and repute if her lamentations are poetical. An acquaintance of mine, who was spoken of with approval, always, from the time of her betrothal to that of her marriage, referred to the latter as to her funeral. To her little brother—the only member of a bride's family that may before the birth of her first child visit her in her husband's house—she said, "When I am buried, you must come frequently to burn incense at my grave." To her elder brothers and to her sister-in-law she said, "After I am dead, do not kill the lizards and the centipeds that may crawl about the house, for it may be that my spirit will come back and dwell in the vermin about my home rather than abide in the grave into which I shall have been put." A gifted girl makes many such allusions without instruction, while the stupid have to be privately taught what to say when they wail their adieus to maiden life. How much of a girl's distress is real and how much of it is piously feigned can be guessed only by those who understand how deeply Chinese character is affected by Chinese customs.

The vexations of a betrothal and a wedding are so great as to have given rise to the proverb, "Don't say you have had trouble until you shall have married off a daughter or brought home a daughter-in-law." The sum of money paid to the bride's parents is usually spent upon her marriage outfit. The smallest dowry is a few suits of new clothing. The wealthy give hundreds of garments, and sometimes one or two bondmaids, with a field that reverts to the bride's family upon her decease.

In this, the Swatow region, the bride is always carried from her father's house to that of her father-in-law in a sedan-chair that is carefully closed and covered with scarlet. She is accompanied by none of her own family. The go-betweens and a messenger from the house of the groom direct the bearers who carry her trousseau with her in a procession along the streets.

Early on the morning of the wedding, the bride is bathed in water in which twelve kinds of flowers have been steeped; has her hair stiffened with bandoline and wrought into a marvelous coiffure with many golden aigrettes; is attired in gorgeous apparel, which she puts on with an appearance of bitter unwillingness, and enters the red sedan-chair weeping loudly. The

marriage procession is headed by a man carrying a branch of a banyan-tree, whose local name is identical in sound with another word which means *completed* or *perfected.* It signifies the fact that all that is necessary to legal matrimony has been done in this case. This leader is followed by two men, each bearing a lantern on a stalk of sugar-cane, the former being a part of the bride's outfit, and the latter rising stage by stage to a climax broad and flourishing, symbolizing the hope that the bride's life may likewise widen out. The next in the file is a man carrying over his shoulder a bamboo, the emblem of rapid increase, having a red bundle of foot-gear on one end of it, and a red coverlet on the other. After him come as many burden-bearers as are necessary to carry all the red boxes containing the trousseau.

On arriving at the door of the house, the bride sees her husband for the first time, and recognizes him, among those who await her, by his rich attire. By previous arrangement, she is first greeted by some woman reckoned lucky and prosperous, in the hope that she will be like the one who gives her earliest welcome in her new home. A mistress of ceremonies that has been engaged to see that during three days all is done according to established usage, throws upon the door-sill some burning straw, half extinguishes it, and leads the new-comer across it, saying:

> "Now, fair young bride, the smoke bestride;
> This year have joy, next year a boy."

This rite is supposed to disinfect the bride from any evil influence to which she may have been subjected by demons or white tigers along her route. She then immediately enters the room in which her red bedstead has been set up, and in which her possessions are all deposited. There she sits silent all the rest of the day, among her red boxes, no one speaking to her, or noticing her in any way except by bringing her food. A feast is spread in the evening for male friends, who have been invited by card, and its preparation occupies the whole household. After the supper, the guests are permitted to see the bride, who is brought forward by the duenna toward the door of the bedroom. In some cases only those who can offer a felicitous stanza are allowed to approach the bedroom door, and there is much rivalry in the composition of poetry to be recited. The stanzas usually contain allusions to posterity, as in the following translations from the vernacular:

> "The bride is high-browed, fair and sweet;
> Like awls her small and sharp-toed feet.
> Brought home this year with honors meet,
> Next year an infant son she'll greet."

> "Fresh twigs upon the pine, new sprouts on the bamboo;
> The groom brings home the bride to rule his house: his field
> To her a thousand-fold its annual crop shall yield;
> And she will be a mother-in-law at thirty-two."

Practical jokes usually accompany the entertainment. Sometimes a guest enters disguised as an aged man, and after persuading the duenna to bring the bride close to him by a plea that his sight is very dim, he suddenly tosses off his cap and spectacles and appears as a hilarious youth. This creates much merriment. Another popular joke is to leave a bundle of fire-crackers under the bedstead, with a slow match so placed as to explode them after midnight, and this is often accompanied by an artificial shower falling through the roof upon the bridal couch. When the guests depart they frequently carry with them articles which they know the groom will require next day, and which he is bound to redeem from them with packages of confectionery. It is said that a merry company of the fellow-students of a groom decoyed him from his house after his wedding-supper, and fastened him to a tree in a copse, so that he should not be able to return home that night. His parents finally induced them to go to release him, but when they arrived at the copse they found he had been eaten by a tiger. To avoid probable discomforts, the groom sometimes conceals himself from supper-time until after the departure of all the guests. The fate of Ginevra would be possible to a Chinese groom, but not to a Chinese bride.

On the second day the young pair worship the images of the ancestors in the main room of the house, and make obeisance to each of the senior members of the family. In the afternoon the last presents are sent off from the groom's family to the bride's parents. They include pork, fish, cakes, and confectionery, according with the amount stipulated at the time of betrothal. During the second and third days all who choose may enter the house and view the bride, and the crowd of spectators is sometimes large. They say:

"We look at the new, and not at the old;
We all have, at home, old things to behold."

The third day is a busy one for the bride, as she must then formally begin her domestic duties. Early in the morning she washes clothes for herself and her husband, under the direction of the duenna. Then this mistress of ceremonies takes her hand, holds it upon the long handle of a ladle, and stirs up the food in a jar, from which she is to feed and fatten pigs. She meanwhile recites a rhyme, of which this is a close version:

"Stir up the swill, make the jar fume;
Raise hogs that are bigger than cows.
Stir deep and long, stir into spume;
Give thousand-weight swine to your spouse."

At noonday the bride cooks the family dinner, under the superintendence of her mother-in-law. In the intervals between other occupations she begins and completes the making of a pair of

trousers for her husband. On no account must she be assisted in this task, or fail to accomplish it before the time for cooking the evening meal, else bad luck may follow all her subsequent career. Some time during the forenoon of this third day a messenger from her mother, usually her younger brother, brings her a bottle of hair-oil, takes dinner with her husband, and returns home accompanied by the duenna, who has then finished her duties.

On the fourth day the bride must rise long before daylight to dress her hair in the complex style of a married woman, and, as she is unaccustomed to performing this difficult work alone, she may succeed only after many trials. She this day lays aside her finery, and takes up all the occupations of a daughter-in-law, serving her elders in various ways, and doing the hardest of the housework.

If she hates her husband, and cares little for the comfort of her parents, she may waste food, break dishes, threaten suicide, and make herself so disagreeable that the family she has entered will soon consider the expediency of marrying her off into another household. If she desires to remain where she is, she strives to please her mother-in-law. A husband who takes the part of his wife against his mother is reckoned unfilial, and has little peace in the home of his ancestors. If he takes the part of his mother against his wife, the wife may be driven to suicide, and this would furnish opportunity for her family to make an inquisition financially ruinous to him. The mother and the wife, each jealous of the man's devotion, are the members of the family who are most likely to be unfriendly to each other. The existence of countless families in which three or four generations of both sexes live in apparent amity under one roof proves that the Chinese have great power of self-repression.

At the end of a month the bride's mother sends her a basket of artificial flowers, that she may make acceptable presents to her young neighbors. No bonnets or other head-coverings are used by youthful ladies in southern China, and flowers are worn in the hair on all festive occasions.

At the end of four months, on a day selected as lucky by a wizard, the bride goes to pay her first visit to her mother, unless some event has made it mystically unsafe for her to leave her present domicile or to enter her old one. The length of the bride's stay in her former home varies in different villages. In some she remains a month in her mother's house, and in others it is considered very unlucky if she does not return the same day, before the smoke from the village chimneys indicates that supper is being cooked. But any circumstance that renders either of the families unclean, and therefore unpropitious to luck, prevents the bride from having this outing. Uncleanliness is of two sorts—

that which results from a death, and that which follows the birth of a child. They are distinguished as that of bad fortune and that of good fortune, the former continuing three years and the latter one month. Were the bride to approach any unclean person, she would herself incur the danger of becoming an occult cause of calamity among her relatives. During the first few months after marriage she must carefully guard against exposure to any influence adverse to good luck.

A neighbor of a Chinese friend of mine had one daughter, an only child, of whom she was passionately fond. The girl was married off when sixteen years old. When the first four months were nearly past, her mother's neighbor died, and her visit to her old home had therefore to be delayed for a hundred days. Before this period of the neighbor's daily worship of the manes had passed, the bride's mother-in-law died, and she had to go into mourning for three years. Just before she put off mourning, she bore a son, and that made it necessary for her to again delay her first visit to her mother's house. Her mother, meanwhile, became subject to hallucinations, under which she frequently saw her child entering her door. She said she could distinctly perceive her face, could discern every detail in her dress, and could hear the jingle of her bangles. She would exclaim, "O my child, you have come!" but, when she clasped the vision, she found only empty air in her arms. At last the daughter, who had all these years been but two miles away, really came to visit her mother. The two embraced each other and wept aloud; and thereafter the mother's hallucinations ceased.

After the first visit, a married daughter may go to the home of her parents at any time, and they, after the birth of her first child, may occasionally go to see her in her husband's house.

NATIVE LIFE IN BRITISH BORNEO.

By D. D. DALY, Assistant Resident.*

THE author gave in this paper a personal record of two explorations which he undertook from the east and from the west coast of North Borneo to countries and tribes in the interior, hitherto unvisited by the white man. Having left Sandakan, the capital of the territory, in August, 1887, and ascending the Kinabatangare, the largest navigable river, the first place of importance reached is Malapi, within twelve miles of the famous Gomanton bird's-nest caves, and the depot for their product. The nests collected here are valued at $25,000 per annum, and the

* Abridged from the author's paper before the Royal Geographical Society.

caves bring to the North Borneo Government a yearly rental of $9,000. One of the vaults in the caves is estimated to be nine hundred feet high. An idea of their population may be got from the statement that a steady column of the swifts (*Callocalia*) inhabiting them has been timed by the watch to fly for three quarters of an hour from one of the apertures. Passing Bod Lagit—"which means the hill to the skies, a legend recording that it formerly reached to the heavens, but, owing to the wickedness of its inhabitants, had subsided to its present height of four hundred feet"—and a hill of limestone called Chuko Besar, which contains some small caves and yields a few hundred bird's-nests each year, the explorers visited one of the owners of the Batu Timbang caves, of which two native rajahs share the proceeds in alternate years. They are situated on the river Quamute, a branch of the Kinabatangare, and are difficult of access on account of rapids. Some of the bird's-nests are of the best white description, but the larger proportion are gray and mixed with feathers. Still further up—three hours' climb from the Melikop branch, and eighteen hundred and ten feet above the sea-level—are the Obang-Obang limestone caves, which had not hitherto been visited by Europeans. The first cave reached after a three hours' climb, the last half-hour of it over slippery, moss-grown, limestone bowlders, is the most valuable, but can be approached only by experts in climbing. The entrance is a small hole, four feet by four feet, and is closed by a wooden grating so as to attract attention to the spot, as otherwise the unwary traveler might suddenly be precipitated to the depths below. Every two months this doorway is opened, and the climbers let themselves down into the caves by means of rattans, and gather all nests, large and small. This makes six seasons per annum. The same periods are observed in the collections at the Senobang caves in the Ulu Penungah. "The seasons at Gomanton, Batu Timbang, Madai, and Segalong number two or three during the twelve months, and these are too few, according to the Tungara tribe. They maintain that, by collecting them frequently—say six times per annum—they procure white nests in first-rate order, though some of these nests are young and but half formed, and that the Sulu traders give them a higher price in consequence. I noticed a great scarcity in swifts and a great preponderance of bats, which might be attributed to the too frequent collection of nests, which prevents the swifts from breeding. The Obang-Obang Mountain runs north and south, and is half a mile in length. There are seven entrances to the vaults from the top of the range, all situated close to each other. Five of these vaults do not contain any bird's-nests, there being no swifts, only bats dwelling there." The only chamber that can be entered by any one who is not an adept at climbing on rattans to

the roof of the vault is only fifty feet high, and contains both bats' and swifts' nests. The bats' nests are similar in form to the swifts', but are made of moss only, which these mammalia pick off the limestone bowlders outside.

At one stretch of the lower Kinabatangare several villages had been abandoned some years previously on account of the ravages of small-pox. When asked their age, many natives would answer that they were so many years old at the time of the last epidemic of this disease. The usual interval between the visitations was eighteen or twenty years; and the old men would sometimes acknowledge to having seen the ravages of three or four epidemics. Another settlement had been abandoned on account of the voracity of the crocodiles, which had mastered the art of overturning boats and devouring their occupants. The crocodiles are very numerous in these fresh-water rivers, and many natives are taken by them every year. At a place further up the river, a large one, fourteen feet long, was towed to the bank close to the house where the author was staying. "There was much joy manifested by the Muruts at its capture, as it had eaten a brother-in-law of the chief. Pieces of the bones and skull were found inside, and brought to the house with a good deal of merriment. A chief who has many wives has usually many brothers-in-law, and he is obliged, in a measure, to assist or support the latter. The loss, therefore, of a brother-in-law more or less is not only immaterial, but rather a merciful dispensation; and so there was as much joy, feasting, and congratulation as if Maharajah Oban had been presented by one of his wives with a new baby."

"The Murut," we are informed, "does not wear any clothes, but sports a bit of bark in front; some strings of colored beads encircle his head, a few charms hang around his neck; he carries a spear as though he feared no man, and annexes a new wife when he is 'off with the old love.' The women and children are much neglected."

Where the river passed through a large uninhabited jungle-forest, "in both banks were compressed heaps of leaves and wooden *débris* from four to ten feet thick, that had been washed down by floods. Where the river-water had washed part of the layers away, the section of the bank presented the appearance of a cutting in a hay-stack. These large deposits, if undisturbed, may, after many centuries of compression, form into coal. At a station near the Batu Timbang caves, where the traveler negotiated with the rajah proprietor concerning the proceeds of the bird's-nests, a dance was given in his honor. In the favorite figures the women, holding each other's hands, moved in one circle, while the men, also holding hands, moved in an outside circle, but in the opposite direction—to the sound of music composed of

gongs tuned to different keys, and wooden drums. The next entertainment was given by a party of some twenty men and women performing an incantation over some medicine which was to be administered to the chief. "They all held palm-branches in their hands, which they waved in graceful unison and in perfect time to the melodious cadence of their voices. The women sang one line, and the men took up the solemn refrain in a sort of Gregorian chant. They danced gracefully, holding each other's hands, in a ring around the mysterious object of their charms; both the dancing and singing are continued until the sorcerer declares that the spell has been worked over the medicine. It should be stated that the Tamhanuahs declare that after death their souls find rest in peace on the top of the great mountain Kinabalu, as their forefathers believed before them." A curious mausoleum was visited at Imbok. It was built of solid bilian-wood, a material of long-lasting qualities, and the ends of the prettily ornamented and fluted posts and beams were carved into grotesque heads of animals. It contained some thirty or forty bodies, and was surrounded by fruit-trees.

At Pemengah, where a police station was established, many of the traders were found living and keeping their stores in houses built upon large bamboo rafts, called lanteens, which were made fast to the banks by rattans. The people at one of the villages near this place had never seen a white man before, and when Mr. Daly first arrived the women and children ran away and hid themselves in one of the back rooms, and the men looked "nervously suspicious." They examined his arms and chest, and were very merry at the idea of his skin being white, "which they seemed to think an absurd freak of nature. . . . They all smoke from morning till night, and out of pipes that have brass mouth-pieces and large bowls, such as are used by the Dusum tribes of the west coast. The tobacco is grown by themselves, and retains a green color by their process of fermentation. . . . They have not yet learned the use of guns or of gunpowder. They had not previously seen a double-barreled breech-loader, and when I opened mine to put in a cartridge, they exclaimed, 'Oh, it is broken!' I brought down a few of the swifts that build the edible bird's-nests, and found them to be very small, and to have a patch of white on the back and tail. The men wear only the loin-cloth; the women have but one garment, viz., a short petticoat, which is kept up around the waist by coils of brass wire; the young girls have, as an addition, coils of brass wire from the ankle half-way up to the knee. The cloth is woven from the thread made from the cotton-trees, *kapok*, that grow luxuriantly around their houses, and the women use the same kind of spindle for making thread as is common among the Dusums of the west coast, holding the cotton

in the left hand and occasionally giving a twist to the spindle with the right hand. The people know of no other minerals besides coal and iron pyrites. Their houses accommodate from ten to fifteen persons, and they do not keep pigs under their houses as other sea-coast tribes are in the habit of doing. Their sleeping-hours are peculiar. No bedding is used, but they sleep on mats till about midnight, when they wake up shivering with the cold of these inland mountains. A fire is then lighted on a large, oval-shaped hearth, that is made of clay in the center of each house, and all the inmates, young and old, sit round the fire until dawn in a crouching attitude, telling long-winded stories, sometimes nodding, and sometimes leaning against his or her neighbor with head resting on the knees. Their chants at night-time are doleful and monotonous in tone. For striking a light, the men carry in their waist-belt a small bamboo prettily carved, in which some tinder and a bit of porcelain are kept out of the rain. By holding the tinder and the piece of broken plate in the right hand, and striking it sharp on the side of the bamboo, the tinder is ignited."

One of the objects of the expedition was to put a stop to the head-hunting raids between the Murut tribe and their traditional enemies the Peluans, the latter not representing a particular tribe, but the aborigines of the interior generally. "The Muruts are very frank in naming and numbering the heads they had taken; and I found the debit and credit account to be as follows: The Muruts have taken twenty-six heads of Peluans, the Peluans have taken thirty-one heads of Muruts; balance in favor of the Peluans, five heads, and also four Muruts who were wounded in the last affray. Each tribe distrusts the other, and peace can be only made by the Peluans paying a commensurate amount of blood-money in compensation for five heads that stand against them." Word was therefore sent to the Peluans to come down to a parley at an appointed time, with guarantee of safe-conduct. When the chiefs of the two sides had been brought together, "the Murut chiefs commenced taking the oath by chopping at a stick or sapling with great vigor, repeating the words of the oath with a loud voice, until toward the end they appeared quite excited. A Murut chief took the oath and then a Peluan, turn about, and, as each oath takes six or seven minutes to repeat, it took a long time. The following is a *précis* of the form of oath, each + denoting a chop at the stick, until it is finally chopped into little bits: 'I follow the Government of the British North Borneo Company +. The Sandêwar + and the Peluan + people are now of one mind +. If I kill a Sandêwar" (if a Peluan is swearing) "man + when I go to the water, may I not be able to drink +; when I go to the jungle may I not be able to eat +. May my father die +, may my mother die +, may my house be burned down +, may the paddy not grow

in my fields +, may a crocodile swallow me +, may the eggs never be hatched in my fowl-house +, may I never catch a fish when I go fishing +, may my life be ended +. I cut this stick + as if I was chopping my own head off +. The Great Spirit is my witness +. May this stick grow into life again + if I ever kill or take any more heads +, and I follow all the customs of the British North Borneo Company +, and I take this oath with a sincere heart +, and I shall pay the poll-tax of the company +."

One of the Murut chiefs "was chopping away at the stick, repeating the oath in a loud voice, when he came to the part 'may my wife die' (if ever I take another head), when he stopped short and exclaimed with a grim smile: 'I have no wife; you Peluans cut off her head long ago'; and the Peluans gave a shout of laughter in which he joined, the crowd around rolling on the grass, convulsed with merriment. This would denote that the retaliation in taking heads does not proceed from a spirit of affection for the departed relatives, but rather from a sense of revenge or *vendetta*, engendered by a feeling that shame has been cast upon the tribe by losing one of the family at the hands of the enemy. Another illustration of the indifference with which the people regard the head-hunting custom was afforded at a chief's house where fifty-two human heads and pieces of human bones were hanging from the rafters. The skin of some of the faces was so well preserved that the expression could still be recognized." Mr. Daly explained that he could not eat his evening meal in a room where these were suspended, and asked that they be cut down. This request the chief and his sons "cheerfully complied with, but with a bland smile of patronizing pity at the white man's amiable squeamishness; and so to humor me they took down the ghastly trophies, and, huddling them together in rattan baskets, put them away at the back of the house; doubtless they were reinstated as drawing-room ornaments after my departure."

It is claimed that great improvement in the order and civilization of the country, and in personal security, has already resulted from the occupation by the British North Borneo Company.

THE higher scientific deductions, which could not have been reached without the aid of a faculty in which imagination had a share, are in standing contradiction to the often-repeated *dictum* that science is void of imagination and the play of thought. Newton, Kepler, Bacon, Helmholtz, Lyell, Owen, Darwin, and Pasteur, are cited by a writer in "The Lancet" as scientific investigators representing the very highest type of intellect, in which the insight and imagination of the poet were united with the capacity for severe and sustained observation. To represent scientific study as affording no play for emotion is false. "No poet's fancy can equal in grandeur the two twin generalizations of science, gravitation and evolution—the one binding together the universe of matter, the other uniting into a harmonious whole the universe of life."

ANIMAL ARITHMETIC.

By Madame CLÉMENCE ROYER.

ALL degrees of arithmetical aptitude may be found among the human races, from the genius of a Newton and a Laplace to an absolute inability to conceive the abstract notion of number aside from concrete facts furnished by direct perception. The savage is not deficient in the perception of the multiple. He never confounds one tree with two, or two with three, or four; and is well aware of the difference between two, three, or ten men, when he is going out to fight them. The thing that he can not do is to abstract the idea of a number from the things to which it is attached, and generalize it, without reference to the concrete objects with which he has seen it associated. He may comprehend two, because it is associated with his two hands and his two feet; three, by the aid of the triads with which he is acquainted, and of the triangle with which those objects may be arranged; four, from the four limbs of animals and the four corners of a square. But his ability to form such conceptions is very limited. The first steps in learning in this direction, in savages and children, are to distinguish the abstract notions of unity and plurality, and in plurality, of two and three from larger pluralities. The difficulty in the way of their reaching a concept of abstract numbers is their inability to form a mental representation: four trees not being identical in the savage's thought with four stones, he can not imagine that there is anything common between them. Nevertheless, he can distinguish clearly enough between four trees and three others, and the two groups will leave quite different impressions in his mind. Four trees in a row will also make a different impression from four trees in a square. He is most struck with differences of distribution in space, and derives from them his notions of differences in plurality. While he is a poor arithmetician he is a good geometrician.

It is by the exercise of this faculty that he finds his way so readily where he has once gone. He recognizes a wood he has been in by the relative distances apart of the trees, their heights, sizes, the inclination of their trunks to one another, the profile of their masses, and their kinds. He learns the landscape by the relief and accidents of the ground, the wave-lines of the horizon, and a thousand details which he fixes upon his memory by a single keen observation so clearly as to give imagination no chance to play tricks with him. He estimates distances by the weakening of tones and the convergence of the lines and planes of the

perspective. But in all his comparisons of present and past sensations, definite notions of number rarely have any part.

The inequalities in the development of the power of counting and of arithmetical notions among the different human races should make us cautious about accepting the accounts of those who believe that some animals can be taught to count. It is extremely improbable, at least, that animals, however intelligent, without language, should acquire precise ideas which human beings succeed in apprehending only by the aid of language and education.

The animal can distinguish relative sizes, but the measure of quantities escapes him. Like the child and savage of inferior development, he can only distinguish between few and many, between unity, duality, and plurality, the various degrees of which must inevitably be more or less confused in his perceptions. He knows facts, but he distinguishes them chiefly by their order of coexistence in space, rather than of succession in time; and they are photographed in his brain in views of the whole, of which, not being able to separate them from the others, he can not distinguish the similar parts enough to count them. His recollection of places is a succession of kaleidoscopic pictures, in which, among the moving forms and successive sounds, he marks only what moves him, what gives him pleasure or pain, what flatters his instincts or answers to his wants, what arouses fear or desire in him. If he should go so far as to count, it would be only those objects which interest him with a view to his security.

The wolf and the fox, for instance, can distinguish whether a flock is guarded by one or two dogs, but can not tell any better than we can how many sheep there are in the flock; but if they see one or two separated from the rest, they will attack them. In the same way we can distinguish the forms of two, three, or four poplars on the bank of a stream, while we can not tell the number of trees in an avenue, but are always inclined to exaggerate it.

It is by this observation of lines, directions, and signs in the whole, rather than of numbers, that the animal acquires the faculty of recognizing roads it has passed over, and places where it has met its prey or escaped its enemies. It can orient itself to the horizon and measure distances, as the savage does; and, like him, it has the sense of the direction it ought to take to reach the object it is in search of; but it is reasonably certain that no calculation of any number of units enters into this intelligence. When a dog in hunting crosses a wood or a fallow ground, he is able, by a quick apperception, to describe all the curves and all the angles that permit him to avoid or turn the obstacles. He can adjust his leap to the width of the ditch which he has to jump,

and find the point where he can pass a live hedge. This mechanical instinct is exercised spontaneously in him, by virtue of exact theorems of which he has no analytical consciousness, but which he applies with a precision that defies the ingenuity of mathematicians. Force, speed, mass, space, and time are calculated in an equation in which the means are closely adapted to the end, with a marvelous economy of efforts, and by the quickest if not always the shortest way.

In his relations with man, attentive to the will of his master, whose language he has learned to understand, partially at least, the dog comprehends whether he must go or come, run or stop. But he attends less to the phonetics of the words than to the intonations of the voice, the direction of the glance, and the gestures.

The horse knows whether he is to go to the right or left by the energetically pronounced interjections "gee" and "haw," but he measures the extent to which he must veer in either direction by the pull on the bridle, so much as to turn quite round if the pull is at once energetic and quick. If the strees is equal upon both sides, he stops abruptly on his haunches. He learns the language of the stable in a very short time, much less than it takes to train the horseman. But there is no notion of numbers in it, although the horse is very sensitive to musical rhythm.

We can not, at a glance, estimate the number of men in a regiment, but we can calculate it rapidly, when we have noticed the number in a line, the number of lines in a company, and the number of companies. We are still more incapable of distinguishing one hundred points in rows from ninety or one hundred and twenty, without dividing them into tens. But an animal, which has no faculty of numerical abstraction, or of unities of different orders, or of multiplication, would be absolutely incapable of performing this operation. When small numbers of concrete things are in question, however, the aptitude of animals to distinguish these numbers is evident, and is, moreover, indispensable to their existence. A wolf or a boar, which could not perceive how many dogs were attacking it, would not know how to defend itself; but, if it counts them, it is by means of the tactics by which it opposes them, and in which it follows geometrical rules; for if four dogs attack it, two on the right and two on the left, it retreats, facing them, so as not to be between them, but to hold them as much as possible in front and within reach of its tusks. But if the pack is too numerous, the animal becomes wild, loses a clear notion of the number of its adversaries, and bites at hazard the one which presses closest upon it. A man in a similar situation would do much the same.

Birds have at least a vague idea of the number of eggs in

their nests, for we can not take one out without causing in them a disquiet that becomes greater if we remove more. But they manifest a like distress when their eggs are only disarranged. Is this because the geometrical arrangement of the eggs is changed? Five eggs or four make a symmetrical arrangement as the bird disposes of them. But if some are taken out, and three, or two, or one are left, the disposition is very perceptibly changed. When the little birds have been hatched, the differences in their size, liveliness, figure, and voice, give the mother a means of distinguishing them individually. And even the eggs are perhaps not so indistinguishable to her as to us; for sexual and maternal instinct conveys special faculties in these matters. The domestic fowl seems to be less intelligent in such things than sparrows and other wild birds, but this is because domestication has modified her instincts.

Cats certainly know how many kittens they have, but they seem less affected by the loss of one of them according as more are left. If the mother loses one of four or five, she seeks for it a little while with considerable anxiety, and then becomes reconciled to the loss. If only one is left, she becomes greatly troubled, and, if that is taken from her, her distress appears extreme. This may be because of the pain she suffers in her teats when the milk ceases to be removed. When the young have become weaned, she can witness their disappearance with apparent indifference.

Dogs have been observed on various occasions to exhibit primary numerical perceptions in the concrete. When there are a number of them in a house, they quickly remark the absence of one of their companions. But they are rarely troubled by it, and make no effort to find the missing one, and they are still more ready to take notice of the absence of one of the members of their master's family. These traits are more easily explained by the clear knowledge which dogs have of individualities than by ascribing to them notions of unities as forming parts of numbers. The unequal degrees of attachment which they show for the different members of the family, and for the different persons who live in the house or visit it, proves that they make great differences between them. The idea of difference between several persons involves and supports a notion of their number. But it may lie there if wrapped up in their total perception.

Hounds pursuing a hare are troubled for an instant if they raise another one, and will sometimes stop, as if they were uncertain which one they ought to follow. Good dogs will not allow themselves to be diverted from the scent of the first animal, which they have already tired. When the setter pauses before a flock of partridges, the movements of his head and eyes follow the birds that stray to the right or left. If the flock is large, he can not

estimate their number, nor can the hunter. The shepherd's dog watches his flock of sheep, and goes after the individual members that wander from it. But if one or two of them have been sold or carried off by a wolf during his absence, he does not miss them.

It is wholly improbable that the so-called learned dogs, which are said to have been taught to count, have really been lifted to the abstract notion of numbers. They have simply been taught to associate certain signs or words of their master with particular graphic signs, the geometrical figure of which has been impressed upon their memory. In the same way that the horse associates the words "gee!" and "haw!" with his right and his left, and dogs associate the sound of the horn or trumpet with the chase, they may associate with figures which are shown to them the names as pronounced of those figures, but without comprehension of their numerical relations, and without distinguishing them in any other way than by the difference in their shape. They may be taught to arrange them when commanded in any particular order, without it being necessary to suppose that they have any idea of their arithmetical significance.

When Sir John Lubbock speculated about teaching his dog to read, he played upon this faculty of associating vocal signs with certain forms or figures, and even with graphic signs, figures, or letters. The dog certainly had no comprehension of the ideographic value of the figures which were shown him drawn upon the pasteboard; but their shape, stamped in his memory, was associated with the sounds that were spoken to him when they were shown him, and with certain acts that he was to perform to obtain caresses and rewards from his master. He thus soon learned to pick out the cards which he had to bring to ask for drink or food or to go out in order to have his desire satisfied. The quickest way of teaching children to read is to show them at the same time the image of the object and the word that designates it, so that the two shall be associated in their minds, and they are tempted to speak in the same way. But to appreciate the abstract sense of the noun or the verb requires a degree of intelligence and faculties of comparison which none of our domestic animals has as yet attained.

It would, moreover, be very extraordinary to find in an animal so far removed in organization from man as the dog a *quasi*-identity of mental faculties, and an educability which is wanting in entire human races. It is enough to show that between the intellectual state of dogs and of Bushmen, Tasmanians, and Veddahs, who can count only two, and then say "many," the difference is as slight as possible, and the passage insensible.

It is, moreover, evident that horses and dogs know as well as

a savage that they have four limbs. Foxes caught in traps will use the most ingenious devices to extricate themselves, and will even gnaw off one of their paws rather than be prisoners. This requires an effort of the will contrary to the instincts, surpassing the degree of moral energy of which most men are capable; and, further than this, the act demonstrates a power of applying means to the end, which is an act of intelligence not less complicated than the effort required for counting twenty on the fingers and toes, as is the manner with most savages.

The faculty of abstraction and generalization is developed exclusively by the aid of descriptive and ideological language, which classifies things and acts under different words or auditive images. With inferior races this faculty is weaker in proportion as their language is less analytical and less rich in abstract terms. It is impossible to excite it in an animal, because, in the absence of a language common to man and him, he is destitute of every means of acquiring it. There is really no bridge between animal and human intelligence. While our language, being descriptive and objective, associates a sound with each visual image, the language of the animal only expresses emotions and passions. As a rule, it is as untranslatable to us as our language is to them. It is only when we try to paint, describe, relate, and express ideas, that they can not understand us, for nothing is easier than to cause them to share our emotions, tenderness, anger, or hatred. They understand our mimicry better than we can understand theirs, and by mimicry we can make them understand the causes of our emotions of a certain kind. The only condition is, that we be dealing with species of a social nature.

When a hunting-dog sees his master with his gaiters, carrying his game-bag and gun, he understands that he is to go with him. He may even have acquired the habit of associating the recollection of a sound with these objects, and thus know the names by which we designate them in the language which he hears us speak. He may also be taught to fetch the gaiters, shoes, and game-bag when told to do so. If, when he has brought one shoe, he is told to fetch the other, he understands that there are two. To this point he certainly has the notion of duality. He can not be ignorant, after he has executed this order several times, that the words "the other" mean the second shoe. If, after having been trained by an English master, he passes over to a Frenchman, he learns that his order *l'autre* means the same thing. He takes no notice of the difference in the sound of the words, because they are both uttered with the same accentuation and intonation, and under the impulse of the same feelings. To him human speech is a yelping, which he interprets by the same rule as he does his own ejaculations.

A second unit, added to the first, is in reality the beginning of all numeration and the foundation of arithmetic. As there are human races that have never gone further, we need not be surprised if animals stop there. But they do not stop there. They go on from this by successive additions, while we have reached the stage of multiplication, and have framed arbitrary systems of numeration, and have thus made of calculation an art founded on ideal notions. Animals, on the other hand, have a concrete notion of numbers more highly developed than we suppose, and perhaps more highly developed than it is with us, in proportion as abstraction is less easy with them. We need not suppose that the animal is destitute of all abstract notions and incapable of all generalization. Far from it; but the general notions being made of resemblances and the individual notions of differences, it is more struck than we are by individual characteristics. In this it again approaches the child and the savage, neither of whom has the generic notion of man. The child has the individual notion of its mother or its nurse, whom it distinguishes from all other persons around; but the generic notion, composed of all the common traits of the persons around, is of slow growth. The languages of savages are, for the most part, wanting in words for *tree* or *animal*, to comprehend the class, but have definite names for all the trees and animals that are useful to the tribe, or which they fear. We, therefore, may affirm that the dog has no generic idea of man, animal, or plant, but only ideas of particular men, particular women or children; and that every species, whether of animal or plant, is thought of by it as a representation of its individual figure, with all the differences that distinguish it from the others that it has seen. Our imagination by itself can not bring up the idea of an animal or plant which is not a particular animal or plant; and any effort we may make in this direction will end in there passing through the mind a succession of images of different animals and plants. If the use of generic names is taken from us, the general notion will go with it.

In the absence of articulate and descriptive language, and there being no object competent to serve us as a phonetic and auditive representation, we would think directly of things by a kind of precise interior view that permits no error or verbal sophism, and not as by a kind of internal audition that tends to replace things by their names, that makes us speak our thought within ourselves before speaking it aloud, and which we mistake as well as deceive others, when the interior definition which we give to the words does not correspond with the thing defined. It is especially difficult, in the absence of a common language between man and the animal, to make the latter comprehend what we require from it, and the object of the acts which we solicit it to perform. The

dog has no desire except to obey and please us; the trouble is in explaining to him what we want of him.

A dog had been taught to go, when commanded, to the shed for wood for the fireplace. The exercise amused him; and, when he had brought one stick, he liked nothing better than to return for another, so that he had to be told to stop. But one time, when he was alone and lonesome, he pulled down all the wood, stick by stick. He had not comprehended the purpose of the act which they made him perform, supposing it to be a sport, like the ordinary carrying of a stick. Could this dog have been taught to count by sending him for two sticks and then for three, and so on to larger numbers? We doubt it, because he had not even disengaged from the act which he was ordered to do the general idea that all the pieces of wood which he brought were to be burned in the fireplace, that he was never sent for them except for that purpose, and that he should only fetch as many as were needed.

If efforts to educate animals have been even more fruitless in the hands of scientific investigators than of workingmen proceeding without theoretical views, it is because great errors have been committed in the analysis of human faculties, in making such suppositions, for instance, as that arithmetical notions are more elementary than geometrical ones. Having done this, they have sought to teach animals, whose capability is for measuring, to count. Having become habituated by our industrial civilization and the economical laws of exchange to the intervention of the idea of number in all our wants, acts, and works, we have lost perception of the insignificant part which it has in animal life as compared with that of the idea of size. Animals have a very exact sense of size. They can measure time and distance better than we can. The sparrows in our parks, when affecting the highest degree of confidence in us, know how to keep just enough distance from us to be able to evade us. It also seems to be demonstrated that all animals have more or less of the faculty of estimating the number of objects coexisting in space; that is, in a varying degree, of analyzing the similar or identical elements in their visual or auditive perceptions, so long as the number is small enough.

Have they also the faculty of estimating numbers as successive repetitions of the same facts in time, or of counting the reiteration of the same perceptions? I was once told of a workman who was in the habit of giving sugar every day to a dog which he met in going to his work. The dog counted on his daily return. He gave three pieces of sugar, one after the other, and the dog would wait and look till it had got the third piece, when it seemed satisfied and did not ask for any more. It had, therefore, the notion of these three successive facts, and could count them. I learn

from good authority that a tame sparrow was accustomed to go out daily from the house where it lived in freedom just before it was time for the children to come out from school. It would wait at the school-house door for a child of the family with which it lived, and return perched upon its shoulder. One day it went out but did not return, having probably fallen a prey to a cat.

Nothing is more frequent among animals than daily acts at fixed hours; but we have proof also that animals can measure longer periods. A dog was used to go every Saturday evening for his master, who came to spend Sunday at home, and went away again on Monday. But the dog, instead of following his master away, showed his displeasure at the parting by sulking in a corner. Could this dog count the six days of the week during which his master was absent? It is more likely that his return was foreshadowed by certain things going on in the house that only occurred on that occasion.

Houzeau de la Haie tells of a pelican living in a fisherman's family at Santo Domingo that was fed upon the refuse of the fish-cleaning. Looking for its food, it went to the shore every day and waited for the boats to come back. The fishermen rested on Sunday, and the bird acquired so clear a notion of the return of that day, when it had to fast, that it would not stir from the tree on which it was accustomed to spend its time. It is not necessary to suppose that the pelican had learned to count the six days at the end of which its masters would not go fishing; but, while it really estimated daily the time when it must make its excursion to the shore, it was informed of the return of Sunday by observation of what was going on in the house, as, for instance, by the fishermen putting on their Sunday clothes; in the same way as the dog knew when its master was going to hunt by seeing him with his gun and game-bag. In such instances, animals show that they have the faculty of associating ideas, of observing consecutive facts, and establishing a correlative connection between them—things which have been proved by abundance of other evidence, and which demonstrate not less intelligence than acquaintance with the ten signs exposing the first ten numbers, or the use of a system of numeration to express larger numbers.

Broderip tells of an English Protestant minister's dog which escaped every Sunday and followed its master to church. It was shut up on one Saturday evening, but on the next week when they went to shut it up it could not be found, and hid itself till the service-hour on Sunday, when it appeared again at the church. In acting thus, it had evidently reasoned out all its conduct, displaying memory, foresight, and calculation. It is not likely, however, that it acted upon a count of the days, but rather on the

knowledge that it had to turn the spit on Saturday, or the day before its master went to church.

If this period of the seven days of the week does not exceed the intelligence of a dog, the dog should be able easily to measure periods of two or three days. Houzeau says that he tried for three consecutive weeks to repeat the same walk with his dogs, every two days at exactly the same hour. It would have been enough for them to count two to determine the period. On the twentieth day, or the tenth periodical repetition of the excursion, although the dogs enjoyed the excursion exceedingly, he never remarked that they anticipated it spontaneously, or had a thought of it before witnessing his preparations to go. From this, Houzeau concluded that dogs could not count the days. But when actions repeated daily at fixed hours were in question, the dogs knew when the time came. Broderip's dog and the Santo Domingo pelican had learned, in the course of years, that the same succession of events took place every Sunday. It was not, therefore, by an isolated fact, but by an aggregation of facts, that they became aware of the return of that day; for not only did certain things take place regularly in the family, but Sunday noises, like the ringing of the bells, and unusual comings and goings, occurred in the place. After continued experience, the animals acquired knowledge of the succession of the events, and governed their conduct accordingly.

Houzeau also learned that some animals are capable of measuring lapses of time that particularly interest them. He says that female crocodiles abandon their eggs in the sand for ten or fifteen days, according to the species, and return to the spot at the exact time when they are to be hatched. It is easily conceivable that animals have, in general, a more precise measure of periods which concern the needs of their organic or specific life, than of the more artificial periods to which they have become habituated in the domesticated state or in consequence of their relations with man, because an hereditary habit has always more force than habits acquired by education.

Houzeau cites facts showing that some animals can count the number of similar objects or acts, provided the numbers are not too high. When a magpie is watched by a company of hunters, it will not move till they go away. If they go one after another, it can not be deceived by one of them staying behind unless there are more than four of them. Another story of similar bearing is that of the tramway mules at New Orleans, which are relieved and fed after making five trips. They make their trips patiently and quietly till the end of the fifth, when they give evident signs that they expect their usual refreshment. The horses in the coal-mines of Hainault make thirty trips a day, taking their places

again, after every trip, at the head of the train, in readiness for the next trip; but at the end of the thirtieth trip they turn their heads in the opposite direction, or toward the stable.

Facts of this kind ought to be tested by most precise experiments bearing upon the conditions under which they are produced, and upon different subjects. Are not the horses warned of the end of their stint by some exterior sign, such as a change of conductors, the departure of a squad of workmen, or the arrival of the horses that are to take their places, or by the meal-hour? Is not the conclusion that they count the number of their trips arrived at too quickly?

It would predicate a very high degree of development to suppose that a horse could count up to thirty in any given number of hours. A man in such case would nearly always make mistakes, unless he had some means of registering the trips as they were completed.

It is nevertheless established that some birds and quadrupeds are capable of counting up to four or five, and perhaps more. It can not be disputed that the higher limit of this faculty may vary according to species, and also to individual traits, since the mathematical faculties of men are very great in their variations. But we have reasons for believing that the geometrical faculty in animals supersedes the arithmetical faculty, and that the latter has been developed in man under the influences of industrial civilization and commercial exchanges, which have, in nearly all cases, caused the notion of numbers to be substituted for that of measure.—*Translated for the Popular Science Monthly from the Revue Scientifique.*

SKETCH OF F. A. VULPIAN.

THE name of Vulpian is associated in some way or another with most of the important physiological discoveries of the age. It is, according to Dr. Charles Richet, because, whenever a new experiment was published, he took it up at once, tested it, and perfected it, toning down with his critical and judicial spirit the exaggerations and rectifying the errors in the accounts, and, making the general application of the newly gained fact, gave it the right to be quoted as good physiology. Thus he cast light on all the problems which he grappled with.

EDME FELIX ALFRED VULPIAN was born January 5, 1826, and died in Paris, May 18, 1887. He was the son of a distinguished French lawyer, and was graduated in medicine in 1854. He was soon afterward appointed to the Museum of Natural History, where he conducted a series of investigations on the nervous sys-

tem; was admitted to the Medical Faculty, Paris, in 1860, with a thesis upon secondary pneumonias, and was made one of the physicians at the Salpêtrière; was appointed, in 1867, Professor of Pathological Anatomy; in 1872 was transferred to the chair of Comparative and Experimental Pathology; and in December, 1885, became Dean of the Medical Faculty. As professor he made it a point to perform new experiments in his courses every year. In fact, says Dr. Richet, all his lectures were marked by ingenious views, novel experiments, and important bibliographical data, to such an extent that they could be published as they were, almost without modification; and they constituted excellent monographs.

The anatomy and physiology of the nervous system was his favorite field of research. Next to Claude Bernard, says one of his biographers, he studied with the most particular care, in the minutest details, the nature and functions of the vaso-motor nerves, and the laws of their contractions and dilatations, the general effect of which on the mechanism of the functions is so marked. His lectures on these organs, with those upon the action of toxic substances and medicines, and upon the diseases and physiology of the nervous system, are regarded by Dr. Richet as works of the highest order, which gave definite shape to our knowledge on the most important points, and as containing an "incredible" number of precise facts that have become indispensable to the practitioner. Among these labors, those upon the action of curare, chloral, and strychnine have become classical. The localizations of the functions of the different parts of the cerebro-spinal apparatus, and the effects of alkaloids on these parts, occupied him for a considerable time. He was an eminent physician as well as a skillful physiologist; and in this capacity was called upon to attend, during his last illness, the Comte de Chambord, whose disease baffled the skill of the doctors.

Dr. Charcot, in his funeral eulogy of Vulpian, said that "he might be characterized in a single word—as a man of duty. He was never known to retreat from a task which he had engaged to perform. As soon as he felt his strength declining, he resigned the much-coveted post of physician at the Hôtel-Dieu, five years before reaching the limit of age, and at the same time gave up the civil practice which he had carried on for several years with great success as consulting physician. This was because he wished to employ all of his time in the service of the Academy, and we all know how he discharged his duty in this relation. Vulpian was more than this: he was a man of great and good heart; a man ready to sacrifice everything for his family; a master adored by his pupils; a sure and devoted friend; and I, who have the sad honor of being your speaker, can not recollect without strong

emotion how, in the numerous and warm competitions in which we were engaged with one another, Vulpian was always a loyal, generous, and chivalrous rival.

"Although he performed high administrative functions, particularly as Dean of the Faculty of Medicine, he met but few enemies, and these, I believe, belonged to that class of unfortunates who can not come in contact with superiority of heart and mind without having a kind of feeling of irritation and despite. But we may let them pass.

"During the last few years, the condition of Vulpian's health had gradually changed. Then I heard him repeat what he had said to me thirty years before, just after the death of his brother, of whom he was very fond, 'I hope to restore myself by work, a remedy which we are fortunate to have.' Yes, work—always work—was his supreme refuge. The last struggle was one to which he was unequal, but yet we observed him making most courageous efforts to keep himself in the ascendant. He came to the Faculty of Medicine daily with the same order and punctuality that had marked the earlier part of his career, to take up and carry on, as long as his strength permitted him, the lectures which he had conscientiously prepared. At the Institute he performed his difficult duties with that scrupulous zeal and distinction which we have all been pleased to recognize."

M. Vulpian earnestly supported M. Pasteur in his late researches concerning the microbes of infection, and particularly in his investigations and experiments concerning hydrophobia; and when it fell to him to defend the daring inoculator and his intensive system of treatment against attack, he did it in the Academy of Medicine and the Academy of Sciences with a vigor that evoked the applause of the members of both bodies, and silenced M. Pasteur's adversaries for the time. Nevertheless, the intensive treatment has prudently been suspended.

We have been favored with the following grateful reminiscence of Prof. Vulpian by one of his former students, W. W. Skinner, M. D. (Paris), of New York: "It was seven years ago when the pursuit of my medical studies first brought me into contact with this truly great medical teacher. He was then Dean of the École de Médecine of Paris, a position only obtained by the wisest and most learned of the great corps of professors in that school, and which confers upon the incumbent the highest honor that his colleagues can bestow upon him. At the same time, he was Professor of Experimental and Comparative Pathology; and his demonstrations of the pharmacodynamic actions of the most active substances of the materia medica brought a roomful of interested students to his laboratory three times weekly during the summer semester.

"One Tuesday, at the usual hour of his demonstrations in the laboratory, he gave us students an agreeable surprise, and one which we shall long remember. He had invited the renowned Pasteur to show to the class the results of his researches in his now world-famed methods of prophylaxis by vaccination of many virulent diseases of the lower animals. For the short hour of the lecture, Pasteur took chicken-cholera for his subject. He showed the students the micrococcus which causes the disease, the manner of converting it into a harmless vaccinating matter, and finally the lesions produced in the unvaccinated fowl by the micrococcus. Prof. Vulpian, in his large-hearted admiration for his fellow-scientist, took a real pleasure in giving his class an opportunity of seeing and hearing Pasteur.

"The personal appearance of Prof. Vulpian was more than usually striking. He was above the average in stature, and his broad but slightly stooping shoulders were surmounted by a large, finely shaped head, which was adorned by a thick growth of wavy, iron-gray hair. His grave and dignified mien, and the modest air of a true *savant* that he constantly bore, at once commanded the respect and consideration that he so well merited. His kindly disposition of character endeared him to all with whom he came in contact; and the generosity and absence of jealousy with which he welcomed any discovery made by another scientist, or any honor conferred upon a colleague, was another trait in the character of this truly estimable man.

"He lived in the rue Soufflot, that short but fine street in the Latin Quarter of Paris which is closed at one end by the Pantheon, where the remains of Victor Hugo rest, and at the other by the beautiful Jardin du Luxembourg, where stands the stately palace in which the Senate sits. In this remarkable garden of the Luxembourg, full of fountains, statuary, flower-beds, orange-trees, and students, the hero of this sketch was fond of walking after dinner. Almost every evening about sundown he could be seen strolling quietly through the garden, during half an hour, in company with a tall young man whom I supposed to be his son, and with whom he kept up a pleasant, fatherly conversation. Then, before the *retraite* sounded, which was the signal to close the gates, he would return to his home close by, where his arduous professional work awaited him.

"During the progress of that hot debate which took place last year in the French Academy of Medicine upon the value of Pasteur's method of vaccination as a means of preventing the outbreak of hydrophobia after the bite of a mad animal, Prof. Vulpian gave proof of his excellent judgment in medical controversy, and of his unshaken friendship for Pasteur. In the session of January 18, 1887, he made a warm defense of Pasteur's method,

and, in closing, used these memorable words: 'The glory of Monsieur Pasteur is such that many envious teeth will be broken upon it. Our works and our names will long be buried under the inconstant tide of oblivion, when the name and the works of Pasteur will still be resplendent, and will shine upon such elevated heights that they will never be reached by that dismal flood.'

"Four months after the utterance of these enthusiastic and prophetic words, Prof. Vulpian was borne to the grave. The members of the Academy of Medicine, the Academy of Sciences, the Faculty of Medicine, and the numerous scientific societies of Paris, participated in the grand and imposing obsequies with which the world-renowned *savant* was honored, and delegates from these institutions pronounced well-merited eulogies over his tomb. The numerous writings from his pen with which medical literature has been enriched will long constitute the highest authority upon the subjects which he investigated."

Vulpian was elected to the Academy of Sciences in the Section of Medicine, when he took the place of Andral in 1876; in 1886 he was chosen perpetual secretary, to succeed M. Jamin. He was given the Cross of the Legion of Honor in 1869, and was made an officer of that body in 1878.

The collection of M. Vulpian's publications gives only an incomplete idea of his labors, which were divided between experimental research and teaching. These works include "Des Pneumonies Secondaires" ("Of Secondary Pneumonias," 1860); and "Leçons sur la Physiologie Générale et Comparée du Système Nerveux" ("Lessons on the General and Comparative Physiology of the Nervous System"). Before the short illness of which he died, he was giving lectures on the respiratory system, and he was about to publish an important book on the cerebral functions.

It is now manifest, says Prof. Judd, that no classification of geological periods can possibly be of world-wide application; and that "we must be contented to study the past history of each great area of the earth's surface independently, and to wait patiently for the evidence which shall enable us to establish a parallelism between the several records." Moreover, while attention was once predominantly given to marine deposits, "the growth of our knowledge concerning the terrestrial floras and faunas of ancient geological periods . . . has constantly forced upon the minds of many geologists the necessity of a duplicate classification of geological periods, based on the study of marine and terrestrial organisms respectively." One of the greatest sources of danger to the progress of geological knowledge at the present day is the tendency to forget that the geological record, although of enormous value, is exceedingly imperfect, and thus to make too hasty generalizations on insufficient data.

EDITOR'S TABLE.

A TEST OF NATIONAL MORALITY.

THE forgery of documents for the purpose of giving fictitious support to doctrines or to territorial claims was a device not unknown to antiquity; and very severe has been the condemnation bestowed upon it by virtuous moderns. The fame of the "false decretals" still lingers in the world; and respectable citizens of our own favored time and country are found wondering how a high spiritual authority could ever have consented to rest its claims, even partially, upon so thoroughly delusive a foundation. Circumstances, however, as has been wisely remarked, alter cases; and that which was very shocking when resorted to for the establishment of principles in which one does not believe, may assume a very different character when found available for promoting the success of the political party that has the honor of commanding the same individual's vote. The "campaign lie" has long been known as a favorite political weapon; but nowadays political mendacity seems, in a peculiar manner, to affect the ancient trick of forgery. The last two or three presidential elections have each had their distinguishing forgeries; but the one just concluded brought the forger's art into a greater prominence than ever before. Men made lies and loved them; and other men loved to see the lies in circulation; and others loved to delude themselves with the lies so made and circulated; until it really seemed as if, throughout a considerable portion of the community, the one thing that everybody hated and feared was truth.

And we are a Christian nation! We hold our heads very high in the world. Our morality is not like that of the decaying states of the Old World, but of a much superior type. We have no royal courts among us to spread servility and corruption; our working-classes are taught to look down with infinite contempt on the "pauper labor" of even such a country as England; our political institutions give every man an interest in the state; and such government as we have is "of the people, for the people, by the people." The theory of our institutions, indeed, is very fine, but we are constrained to say that the practice is very miserable. To have political power in our hands, and then to resort, on a large scale, to falsehood—deliberate, unblushing, reiterated falsehood—as a means of influencing elections, is about as shameful a thing, in our opinion, as the sun shines upon. But, can a thing be politically shameful and yet not dangerous? Fraud and violence are close companions. A quarrel over marked cards is very apt to be settled with the pistol or the knife; and, some day, if political fraud should happen to be just a little too triumphant, we might find ourselves precipitated into another civil war.

Why have we such tolerance for campaign lies and liars? Why do respectable gentlemen, prominent in church circles, either help in the invention of such lies or smile complacently at their circulation? Why is the national conscience so dead on this subject? Has it anything to do with the fact that as yet the morality of science—the morality that consists in the strenuous pursuit and conscientious utterance of *truth*—is so feebly recognized? We have powerful church organizations; the whole land is honey-combed, we may say, with societies for the promotion of a certain type of conventional moral excellence; but what is being done—this, after all, is the question on which the permanence and prosperity of the republic depend—

what is being done to make honest citizens? We know lots of smooth-spoken individuals who are very scrupulous about various matters—much interested perhaps in Sabbath observance; strongly opposed to certain forms of amusement for the young; grieved, possibly, to think that there are people bad enough to hope for the salvation of unevangelized heathen—there are plenty such; but where are the people who hate a lie when they see one, and that without regard to the question as to whose interest is served by it? Where are the men who do not want sophistries served up to them in their favorite newspaper, and who are at all times willing to allow fair weight to a fair argument? In this wide land there are doubtless many thousands who have not bowed the knee to the Baal of political trickery, and who have not imprisoned their souls in any narrow and arbitrary scheme of moral doctrine; but, compared with other types, these are few in number. We meet the man full of church-taught scrupulosities ten times for once that we meet a thoroughly open-minded, honest man. We meet the man who is terribly afraid of doctrinal errors ten times for once that we meet the man who detests the campaign lie. Now, there is nothing to be said against scrupulosity in conduct, nor in favor of doctrinal errors; but falsehoods, the makers of falsehoods, the willing beneficiaries and condoners of falsehoods, and all who leave out of their scheme of life the duty of opposing falsehoods in all their shapes and guises can not be too strongly condemned.

Where is the remedy for this dangerous national habit of political lying? It is to be sought in a reorganized national education. Instead of filling the minds of children with fables, as to a large extent we do, we need to cultivate in them the sense for reality by teaching them to know things in their properties and relations, and natural processes in their definiteness and certainty. In other words, science has to take hold of education and remodel it, until it gives us a generation of citizens too intelligent and with too practiced a sense for truth to fall the easy prey that so many thousands now do to the arts of the political trickster. One may be excused for doubting whether at this moment the political honesty of our nation is really on the increase; but we shall hope that the time may come before very long when science shall do for politics and for morality what it has done for our knowledge of the physical world and of human nature, and give us a regenerated state, the outcome of an intellectually nobler type of manhood.

WORK AT THE LICK OBSERVATORY.

THE great thirty-six-inch telescope of the Lick Observatory has not only more than satisfied the most confident anticipations of what it would be able to do, it has taken the astronomical world by surprise with its revelations. It is not too much to say that it has opened up new vistas of creation, and given to the eye of man so much wider and deeper a range in the universe that, as Prof. Holden, the director of the observatory, has remarked, when looking through this telescope the observer must view objects as if seen for the first time. Celestial phenomena present an appearance, in many cases, so different from that familiar to observers with less powerful instruments that the impression they make is entirely new.

Of course, primarily, the great size and exquisite figuring of the giant object-glass must have the credit for all this, and yet much (very much more, probably, than the general public imagine) is due to the director and his able assistants. Prof. Holden has applied the unrivaled equipment of Mount Hamilton Observatory to the observation of the heavens in a broad-minded way that is decidedly refreshing and encour-

aging by contrast with the manner in which the powers of some great telescopes have been misapplied and frittered away. There are some astronomers who seem to be fearful of nothing so much as that they may be suspected of having done, or said, or seen something interesting. Prof. Holden does not belong in that category, and it is exceedingly gratifying to know that the most powerful telescope on our planet is in the hands of a man who will use it for the broadening of our knowledge of the universe, even at the risk of contributing to the fund of "popular" information.

The discoveries that Prof. Holden has already announced to the world, in the few months since the Lick telescope was first turned upon the sky, are of surpassing interest. We note first the observations of nebulæ, and particularly of the well-known "ring nebula" in Lyra, one of the most attractive of celestial objects even with a telescope of moderate size. In that singular creation Prof. Holden has discovered a marvelous coexistence of rings of stars and nebular ovals, evidently intimately related to one another in a manner that is in the highest degree significant. Then, too, in the nebula known as 37 H 4 in the constellation Draco, Prof. Holden and one of his assistants, Mr. Schaeberle, appear to have discovered a phenomenon of an entirely new order. There a central star is surrounded by ovals of nebular matter which have assumed the form of a helix, and Prof. Holden himself suggests that this spiral or screw-shaped formation appears to have resulted from the emanation of the nebulous stuff from a body that was revolving around the central star while that star itself was moving swiftly through space. His observations promise to make us acquainted with other objects belonging to this same mysterious class.

The director of the Lick Observatory has not scorned to apply its powers to the scrutiny of the well-worn and familiar features of the dead and barren moon, and there too he has found something new and interesting. He believes he has solved the mystery of Sir William Herschel's lunar volcanoes, which that great observer imagined he had actually beheld in fiery eruption.

Some of the most interesting astronomical discoveries of recent years relate to the planet Mars, and foremost are the observations of Schiaparelli, of Milan, on those curious features of the planet's disk which have been called, from their form and their apparent connection with the Martian seas, "canals." Last summer Perrotin, of Nice, announced that one of the Martian continents named Libya had apparently been inundated by a neighboring sea. Not a few astronomers have doubted the existence of these comparatively minute markings and changes upon Mars, because they could not see them themselves. But Prof. Holden and his assistants turned the monster telescope upon Mars with the most interesting results. They confirmed the existence of Schiaparelli's "canals," though they did not see any of them double (doubtless owing to unfavorable conditions), and they found that Libya was still there, unsubmerged. These observations were made some months after those of M. Perrotin; and Prof. Holden suggests that the partial disappearance of Libya, which Perrotin ascribed to an inundation, may have been due rather to some such phenomenon as a veil of clouds in the atmosphere of Mars. At any rate, what were supposed to be such cloud-masses have previously been observed on Mars.

We have called attention to these various observations in order to show in what manner the Lick telescope is being used, as well as to indicate briefly some of the results already attained. We congratulate Prof. Holden and the University of California upon the splendid success of this great astronomical enterprise. The spirit of James Lick, if it can comprehend terrestrial doings

while his body lies under the pier of the great telescope, must be moved with gratification at the complete fulfillment of his desire to build a telescope that should surpass all others in its achievements.

LITERARY NOTICES.

ON THE SENSES, INSTINCTS, AND INTELLIGENCE OF ANIMALS: with Special Reference to Insects. "International Scientific Series," Vol. LXIV. By Sir JOHN LUBBOCK, Bart., M. P., F. R. S. New York: D. Appleton & Co. Pp. 292. Price, $1.75.

THE name of Lubbock will cause the reader to open this volume with an eager interest that will be amply justified. It is an extension of the investigations recorded by the author in his fascinating work on "Ants, Bees, and Wasps," going further into details of structure and function of the sense-organs of insects, together with some discussion of the intelligence displayed by higher animals. In the first half of the book, he gives us the results of his own observations, combined with what other investigators have learned as to the location of each sense in insects, and the structure of the organs in which each resides. He explains the purpose of this part of the work as follows: "While attempting to understand the manners and customs, habits and behavior of animals, as well as for the purpose of devising test experiments, I have found it necessary to make myself acquainted, as far as possible, with the mechanism of the senses, and the organs by means of which sensations are transmitted. With this object I had to look up a great number of memoirs, in various languages, and scattered through many different periodicals; and it seemed to me that it might be interesting, and save others some of the labor I had to undergo myself, if I were to bring together the notes I had made, and give a list of the principal memoirs consulted. I have accordingly attempted to give, very briefly, some idea of the organs of sense, commencing in each case with those of man himself." The list of memoirs to which he alludes is an extended one, occupying eight pages. He begins his descriptions with the sense of touch, "as being the one which is most generally distributed, and from which the others appear to have been in some cases developed. The senses are not, indeed, as already mentioned, always to be easily distinguished from one another; and it would seem that the same nerve may be capable of carrying different sensations according to the structure of the end organs." The inner skin of insects and crustaceans being covered with a layer of horny substance, the sensations of insects, excepting sight, are transmitted by means of hairs projecting through this hard integument. The organs of taste in insects are certain modified hairs situated either in the mouth itself, or on organs immediately surrounding it. Experiments which have been made seem to prove that the sense of smell resides partly in the antennæ and partly in the palpi. "This distribution would be manifestly advantageous. The palpi are more suited for the examination of food; while the antennæ are more conveniently situated for the perception of more distant objects." The antennæ probably serve partly as organs of touch, and some as organs of protection. The author deems it very probable also that some of them, at least, perform still another function, such as hearing, "while some of these peculiar antennal organs," he says, "though obviously organs of sense, seem to have no special adaptation to any sense of which we are cognizant." That insects may have senses of which we are not cognizant, he deems very probable. There are, without doubt, causes in nature which would produce sensations different from any we know of on organs capable of receiving them. For instance, Sir John has shown elsewhere that animals hear sounds which are beyond the range of our hearing, and can perceive the ultra-violet rays, which are invisible to our eyes. Sound and light are both produced by vibrations. The shrillest sound audible to us results from forty thousand vibrations a second, and no light that we can see is produced by less than four hundred million millions of vibrations in a second. "But between forty thousand vibrations in a second and four hundred million millions we have no organ of sense capable of receiving the impression. Yet between these limits any number of sensations may exist. We have five senses, and sometimes fancy that no others are possible. But it is obvious that we can not measure the infinite by our

own narrow limitations. Moreover, looking at the question from the other side, we find in animals complex organs of sense, richly supplied with nerves, but the function of which we are as yet powerless to explain. There may be fifty other senses as different from ours as sound is from sight." It has been thought that the antennæ in all insects are the organs of hearing, but it has since been shown that the sense of hearing is not confined to one spot, and indeed there is no reason why it should be. Grasshoppers and crickets have ears on their legs, and the crustacean genus *Mysis* has ears in its tail. Organs of sight, which are the most complex and varied of sense-organs, are treated in this book at greatest length. In regard to the mode of vision by means of compound eyes, the author supports Müller's view that "the picture perceived by the insect will be a mosaic, in which the number of points will correspond with the number of facets." Two interesting chapters are those in which he describes an extension of his earlier experiments on the power of bees and ants to distinguish colors, and answers the objection that the power which he ascribes to ants of perceiving the ultra-violet rays is not true sight, but a sensitiveness of the skin to light. Recognition among ants he believes is effected to a great extent by the antennæ, whether or not smell is the sense which serves for this purpose. Along with some extraordinary manifestations of intelligence in insects, he tells of some interesting cases of apparent stupidity observed by him and by M. Fabre. The closing chapter is on the intelligence of the dog, and is occupied mainly with an account of Sir John's application to his black poodle "Van" of the method used in teaching Laura Bridgman. The poodle apparently learned to bring a card marked "food," "out," "bone," "tea," etc., according to his wants, but when a card of a particular color, or having one, two, or three dark bands on it, was held up to him, and he was sent to fetch a duplicate from among several cards, he generally failed. The author also discusses briefly the question, "Can animals count?" but has reached no definite conclusion on this point. The mental faculties of man and the lower animals are now being investigated as never before. The problems relating to these faculties are being attacked from many different sides, and while much valuable knowledge is resulting from these labors, a great deal of careless observation, unjustified assumption, and baseless theory is being put forth at the same time. Sir John Lubbock, however, is a careful and patient experimenter and a cautious reasoner, and on every page of his writings he shows that his object is the attainment of truth, and not the defense of pet theories.

DARWINISM. By DAVID STARR JORDAN, Ph. D. Chicago: A. B. Gehman & Co. Pp. 63. Price, 25 cents.

EVERY one who has read any of President Jordan's popular articles on scientific subjects will want a copy of this essay. In it he sets forth, with his well-known vigor and captivating clearness, the main features of the Darwinian theory of the origin of species, and gives samples of the evidence on which this theory rests. He begins by alluding to the variety of the forms of life on the earth, and then calls attention to the unity which exists in this diversity. For instance, "there are dogs and dogs, of all sizes and styles, yet enough alike for us to regard them as belonging to one original species." Then there are other dog-like animals—wolves, coyotes, jackals, foxes—which we must regard as first-cousins to the dogs. Each of these races has still other relatives, further removed from the dog-type, and, proceeding thus, we have at last all animals of the mammalian class "joined together by a branching chain of apparent relationship—a chain of homologies." The problem before us is, "What is the origin of variety in life, and how does it come that this variety is based on essential unity?" The author then reviews the answers which have been given to this problem by Linnæus, Cuvier, Lamarck, Saint-Hilaire, Goethe, and Agassiz. Darwin's answer to the problem follows, and is stated partly in quotations from his works and his letters, and is supplemented by illustrative cases by the author. How Darwinism explains the facts of geological distribution, and of degeneration both of type and of individual parts in the organism, is next explained, and a brief account of the evidence which embryology brings to the support of the theory of evolution, contributed by Dr. J. S. Kingsley, is here inserted.

"The various attacks on the theory of descent," says President Jordan, "have nearly all centered on the question of the origin of man." But these attacks are wholly unreasonable. "Our objections to recognizing our kinship with the lower forms—if we have any such objections—rest on reasons outside the domain of knowledge. They do not rest on religious grounds. . . . Looking over the history of human thought, we see the attempt to fasten to Christianity each decaying belief in science. That the earth is round, that it moves about the sun, that it is old, that granite ever was melted—all these beliefs, now part of our common knowledge, have been declared contrary to religion; and Christian men who knew these things to be true have suffered all manner of evil for their sake." A short sketch of the life of Darwin is prefixed to the essay.

RESEARCHES ON DIAMAGNETISM AND MAGNE-CRYSTALLIC ACTION. By JOHN TYNDALL, D. C. L., LL. D., F. R. S. New York: D. Appleton & Co. Pp. 288. Price, $1.50.

THE researches embodied in this volume cover the first six years of Prof. Tyndall's experimental work. The first investigation of the series treats of the deportment of crystals, and of other bodies possessing a definite structure, in the magnetic field. Plücker had discovered that deportment, and had attempted to account for it by supposing new forces and new laws. Faraday followed and corroborated Plücker, and added one more hypothetical force. These forces were held to be wholly distinct from magnetism and diamagnetism. Tyndall and Knoblauch found a much simpler way of accounting for the phenomena observed, which, in place of the assumption of three new forces, required only a simple modification of known forces, to which they gave the name elective polarity. Prof. Tyndall's first investigation on the subject of diamagnetic polarity is described in the "Third Memoir" of this volume. Supplied with more adequate apparatus and material, he prosecuted the research as recorded in the "Fourth Memoir," subjecting the deportment of diamagnetic bodies to an exhaustive comparison with that of magnetic bodies, which showed that the diamagnetic force had the same claim to be called a polar force as the magnetic. In the "Fifth Memoir" are described experiments made with a very delicate apparatus, which proved that the theory of diamagnetic polarity would stand the severest tests. The application of the doctrine of polarity to magne-crystallic phenomena is the subject of the "Sixth Memoir." Appended to these papers are letters by Weber, Faraday, and Tyndall, relating to the investigations, together with some brief descriptions of apparatus.

JOURNAL OF MORPHOLOGY. Vol. II, No. 1. Boston: Ginn & Co. Pp. 190.

THIS number of the "Journal" contains five papers. The first is a brief account of "Observations on the Structure of the Gustatory Organs of the Bat (*Vespertilio subulatus*)," by Frederick Tuckerman, M. D. This is followed by a paper by Prof. E. D. Cope, "On the Tritubercular Molar in Human Dentition." Prof. Cope has investigated the variation in the number of tubercles forming the crown of the superior true molars in man, and has concluded that "the quadritubercular type of molar crown, illustrated by the first superior true molar of man, belongs to the primitive form from which all the crest-crowned (lophodont) molars of the hoofed placental mammals have been derived; and second, this quadritubercular type of molar has itself been derived from a still earlier tritubercular crown by the addition of a cusp at the posterior internal part of it." He says, further, that "the tritubercular superior molars of man constitute a reversion to the dentition of the *Lemuridæ* of the Eocene period of the family of *Anaptomorphidæ;* and, second, that this reversion is principally seen among the Eskimos, and the Slavic, French, and American branches of the European race." In the lowest existing races the quadritubercular type predominates, while the neolithic dentitions examined are of an intermediate character, thus showing a superior position to these races. The third paper is by C. O. Whitman, on "The Seat of Formative and Regenerative Energy," and deals with the question whether the cytoplasm is a passive body, moving only as it is acted upon by external forces and influences emanating from the nucleus, or whether it has powers of its own which make it capable also of au-

tomatic action. Prof. Henry F. Osborn presents "A Contribution to the Internal Structure of the Amphibian Brain," in which are reported certain studies of nerve-fiber courses and determinations of motor and sensory nuclei. Dr. William Patten contributes a second installment of his "Studies on the Eyes of Arthropods," devoted to the eyes of Acilius. Thirteen plates accompany this number.

INDEX TO THE LITERATURE OF THE SPECTROSCOPE. By ALFRED TUCKERMAN, Ph. D. Washington: Smithsonian Institution. Pp. 423.

THE literature of science is becoming so voluminous that classified indexes are absolutely essential to the student who would obtain an adequate idea of what is going on in his specialty. This index, in its own fullness, illustrates the fact. It is intended to be a bibliography of the spectroscope and spectrum analysis, and to be a list of all the books and smaller treatises, especially contributions to scientific periodicals, from the beginning of our knowledge on the subject till July, 1887. The time covered by this description is not very great, but the number and variety of the titles recorded show how incessant has been the activity of research during the period. An admirable system of arrangement is adopted, under which a strictly alphabetical order of the subjects is followed. Titles have often been repeated more than once, so as to make sure of their being found, and a list of authors is added.

ESSAYS ON PRACTICAL POLITICS. By THEODORE ROOSEVELT. New York: G. P. Putnam's Sons. Pp. 74. Price, 40 cents.

THE two essays comprised in this volume have appeared in "The Century," and are now reprinted in the "Questions of the Day" series. Prefixed to them is an introduction, in which the author replies to the criticism made at the first appearance of his essays, that they offer no cure for the evils they portray, by saying that he attempted only to make a diagnosis of the disease, and not to prescribe for it. He says further that, just as many sick men demand a pleasant medicine which will cure all their complaints without their making any change in their work or pleasure, or their eating and drinking, so certain other men "expect some scheme of reform that will at a single fell swoop do away with every evil from which the body politic is suffering. . . . No law or laws," he continues, "can give us good government; at the utmost, they can only give us the opportunity to ourselves get good government." He then specifies several things that good citizens ought to work for, and says, "Above all, we can strive to fulfill our own political duties, as they arise, and thereby to do each of us his part in raising to a healthier level the moral standard of the whole community." The first of the essays is on "Phases of State Legislation," and is based mainly on Mr. Roosevelt's experience as a member for three terms of the New York Legislature. It reveals a great deal of viciousness and weakness, and also gives credit for a great deal of good work. It contains, too, a number of very amusing incidents. The other essay describes "Machine Politics in New York City," and deals with not only the methods of the men who run politics for the benefit of themselves and their followers, but also the neglect of public duties by respectable men, which makes the doings of political jobbers possible.

MANUAL OF CHEMISTRY. By W. SIMON, Ph. D., M. D. Second edition. Philadelphia: Lea Brothers & Co. Pp. 479.

THE present edition of this manual, while retaining the general character of the first, embodies also a considerable number of changes and additions. The work is specially adapted for students of pharmacy and medicine. It assumes no previous knowledge of chemistry, and hence may be called a text-book for beginners, though it is not suited to the needs of young pupils. The first twenty pages are devoted to a brief consideration of the fundamental properties of matter, and are followed by thirty pages on the principles of chemistry. The author is in the habit of scattering these principles along through his course of lectures, but in a text-book to accompany the lectures he prefers to collect them in one place. The third and fourth parts of the volume are devoted respectively to the consideration of the non-metallic and the metallic elements and their compounds. Only those elements are taken up which have a practical interest, and

for the special benefit of pharmaceutical and medical students space is given to all chemicals mentioned in the "United States Pharmacopœia." The fifth part deals with qualitative analysis, including also a chapter giving the principal methods for volumetric determinations. Organic chemistry occupies a little over one fourth of the volume, and in this department special prominence is given to those substances most important in medicine and pharmacy. In the closing part physiological chemistry is treated, including a consideration of the chemical changes which take place in animals and plants, and of the chemical composition of animal fluids and tissues, with full directions for testing urine. A notable feature of the book is seven plates showing the colors of fifty-six precipitates and liquids, which beginners often have difficulty in becoming familiar with. There are also forty-four cuts representing apparatus.

A Synopsis of the Medical Botany of the United States. By J. M. G. Carter, M. D., Ph. D. St. Louis: George H. Field. Pp. 176. Price, $2.

Dr. Carter has accomplished a laborious service for the physicians of the United States. The book consists of a list of the species under each genus which are known to be useful in medicine, giving their medicinal properties, and telling what parts of the plant are used, and the dose. The medicinal plants of the United States embrace about 140 orders, 620 genera, and more than 1,300 species and varieties. The botanical arrangement is chiefly that of Dr. Asa Gray. The names of introduced species are distinguished by small capitals, and the habitat of rare plants is given. The volume is supplied with a table of orders, and indexes of generic names and of common names of plants, and an index of diseases.

The Journal of Physiology, Vol. IX, Nos. 2 and 3 (Cambridge (England) Scientific Instrument Company) contains eight papers giving the results of laboratory investigations. The first is "On the Physiology of the Salivary Secretion," by J. N. Langley, of Cambridge, and records experiments made to determine whether the "trophic" and "anabolic" fibers of the secretory nerves are paralyzed by atropine at the same time as the "secretory" fibers. This is followed by a paper on "The Physiological Action of Borneol," by Ralph Stockman, M. D., of Edinburgh, and "A Note on the Cause of the Failure of very Rapid Electrical Stimulation to produce Tetanus in Muscle," by Henry Sewall, of Ann Arbor, Mich. "An Experimental Investigation of Strychnine-Poisoning" is contributed by Robert W. Lovett, M. D., of Boston, who concludes that the spinal cord, upon which strychnine exercises peculiar power, takes up more of the drug than the other organs; but whether or not it is more susceptible to the drug than the other organs we have no means of ascertaining. The next paper is "On the Circumstances which modify the Action of Caffeine and Theine upon Voluntary Muscle," by T. Lauder Brunton and J. Theodore Cash; this is followed by a report of an investigation "On the Electrical Organ of the Skate," by J. Burdon-Sanderson and Francis Gotch. The remaining papers are "On the Rhythm of the Mammalian Heart," by John A. McWilliam, M. D., of Aberdeen, illustrated by plates of tracings; and "Further Researches on the Apparent Change produced by Stimulation in the Polarization of Nerve," by George N. Stewart, of Manchester.

Prof. *E. D. Cope* read before the American Philosophical Society in January last a paper entitled *Synopsis of the Vertebrate Fauna of the Puerco Series.* The Puerco formation rests on the Laramie in northwestern New Mexico and southwestern Colorado, and was discovered by Prof. Cope in 1874, and vertebrate remains were found in it by Mr. David Baldwin in 1880. One hundred and six vertebrate species have been found so far, which differ so much from the fauna which preceded and followed them, as to show that this formation represents an immense interval that had not been previously suspected. These species are described in the present paper, and the descriptions are illustrated by two plates, and by cuts showing dentition.

University Studies is the name of a periodical published by the University of Nebraska, at Lincoln, the first number of which, dated July, 1888, is before us. The price of a single number is $1; yearly subscription, $3. There is no announcement of the purpose or times of publication of the journal

in this number. Its contents comprise three papers: "On the Transparency of the Ether," by D. B. Brace; "On the Propriety of Retaining the Eighth Verb-Class in Sanscrit," by A. H. Edgren; and "On the History of the Auxiliary Verbs in the Romance Languages," by J. A. Fontaine. The first paper is an investigation of the phenomena which would occur if there were any absorption of the light-energy of stars by the ether, through frictional forces or imperfect elasticity. The result of the author's calculations is, that the apparent finiteness of the stellar universe can not be due to absorption, as Struve supposed; and that, if the universe is infinite in extent, "the average density of distribution of self-luminous bodies outside our own system must be exceedingly small, as otherwise the sky would appear of a uniform brightness, approximating that of the sun."

In his *Annual Report of the Division of Forestry for* 1887, the chief, Mr. *B. E. Fernow*, defines the work of the division as in the main that of a bureau of information. During the past year the division has distributed different circulars of information to wood-consumers in general, to railroad managers, to educational men, and to members of the National Grange. These, together with a letter to the Commissioner of the Land-Office on what is a timber-tree, are reproduced in full or in substance in the report. The pamphlet also contains statistics in regard to exports and imports of wood and wood products, from 1880 to 1887, and the mill capacity of the country. Seeds and seedlings, mainly of cone-bearing trees and willows, have been distributed to some extent. Mr. Fernow thinks it is time for the division to undertake systematic original investigations. The scientific basis of forest management must be built up from researches in forest biology, timber physics, soil physics, and soil chemistry; its economic basis will consist of forest statistics, technology of woods, and forest policy; and its practical basis will comprise knowledge of methods of planting, managing, and harvesting forests. The report contains notes on certain species of trees, the seed of which has been distributed from the department during the season, telling their value and the mode of their propagation. These notes are followed by statements of the condition of the forestry interests in the several States and Territories.

The Tōyō Gakugei Zasshi ("Eastern Science Journal"), in Japanese, is edited by a committee consisting chiefly of professors in the Imperial University at Tokio, Japan, and has the large circulation, for a country like Japan, of three thousand copies. The number which has been sent to us as a specimen has articles on the primeval world of Japan (accompanied by illustrations of Japanese geology), the aborigines of Japan, the submarine world, "A Great Eastern Problem," and "The Standard Time of Japan," with notes and miscellanies on various subjects, and reviews of books.

The Kitchen, a Magazine devoted to Scientific Cookery in all its Branches (J. H. Lewis, publisher, Chicago), is a monthly magazine devoted to what the publisher justly considers the central and predominant interest of all housekeeping. Subjects pertaining to cookery are presented in an untechnical, common-sense style, and occupy about half of each number. The rest of the space is devoted to matters of different character, the object seeming to be, besides cultivating well the special field of the periodical, to furnish a variety of reading, and make it attractive in other directions. Price, 20 cents each number; $2 a year.

The character of *Chemical Experiments for Medical Students*, by *W. S. Christopher*, M. D. (R. Clarke, $1), has been conformed to the limited time allowed for the study of chemistry in most medical schools. Hence it includes only such methods and facts as the student will need to use in the practice of his profession. It is a laboratory manual, the experiments covering work with the principal metals and acids, using Beilstein's examples. In addition, the more important alkaloids and some organic compounds of medical interest are considered. In physiological chemistry the work deals with the proteids and carbohydrates, the digestive processes, blood, bile, milk, and urine. The acid tests recently introduced for the clinical examination of stomach contents are also given. It is intended to be used with some systematic treatise on chemistry.

We have received from Thomas Prosser & Son, the New York agents of Friedrich

Krupp, a volume entitled *Krupp and De Bange*, by *E. Monthaye*, captain in the Belgian general staff. Its object is to show that the Krupp system of ordnance is superior to the De Bange system, from which it differs in material, construction, and mode of breech-closure. The first chapter is a discussion of various methods of preparing steel for gun-metal; the second compares the construction of the Krupp and the De Bange guns; this is followed by an essay on ballistic performance, and a statement of the extent to which the European states use the Krupp guns. The next chapter answers the objections of the adherents of the French gun against the Krupp, and there is a review of the "Belgrade competition" of 1884, in which a Krupp, a De Bange, and an Armstrong gun participated. An account of a visit to the Krupp works concludes the main part of the book, and to this is appended an analysis by another hand of some criticisms made upon Captain Monthaye's book. The volume is illustrated with diagrams, views, and a portrait of Alfred Krupp.

A decidedly vigorous pamphlet has been contributed to the "Questions of the Day" series, by Mr. *J. S. Moore*, entitled *Friendly Letters to American Farmers and Others* (Putnam, 25 cents). Its purpose is to show the people of the country, regarded as consumers, what the present tariff costs them. The letters are strengthened by abundant statistics, and the following specimen headings will indicate their character: "What it costs the Farmer for Lumber," "What it costs the Farmer for Crockery, Glassware, and Cooking Utensils," "Female Labor on Farms and in Factories," "As to Luxuries and Necessities," and "The Champion Tariff Swindle of the World."

The subject of the next number of the "Questions of the Day" series is *American Prisons in the Tenth United States Census* (Putnam, 25 cents). It is by *Frederick H. Wines*, special agent of the tenth census, and presents the numbers of inmates in the prisons of the country, and the crimes for which they are imprisoned, in a great variety of aspects, such as with regard to birthplace, age, sex, color, length of term, and number of arrests by the police. The figures are embodied in a discussion which includes suggestions for the improvement of certain State and national prison laws. An interesting statement, which reverses the popular judgment somewhat, shows the proportion of prisoners to the number of residents from each of twenty foreign countries. From this it appears that the West Indies send us the most criminals, 1 in 117, while the best showing is made by the Austrians (including Hungarians and Bohemians), 1 in 1,936. The Scandinavians stand next to the Austrians, and the Hollanders are third. The Germans are eighth, with one prisoner in 949 German-born residents, the English eleventh, French twelfth, Irish fourteenth, 1 in 350, Italians sixteenth, and Chinese next below them, with a proportion of 1 in 199.

Two editions of the *President's Message* of 1887 (Putnam, each 25 cents) have been received. One contains annotations by *R. R. Bowker*, which embrace a large number and variety of facts and figures showing the receipts and expenses of the Government for a number of years, the effects of buying bonds at a premium, what the tariff tax amounts to on many items of the consumer's purchases, the percentages of tax laid on important articles at various times since 1789, the variation of wages in Europe and different parts of this country, the amount of wool raised in the United States, the operations of trusts, etc. The other edition is illustrated by Thomas Nast, in his well-known style.

The most extended and important papers in *Reports from the Consuls of the United States*, No. 93 (Department of State), are those on "The Cost of Manufacturing Print-Cloths in Massachusetts, Lancashire, and Switzerland," by J. Schoenhof; "The Province of Kiang-su," by J. D. Kennedy; "The Exhibition for the Prevention of Accidents to be held at Berlin in 1889," by F. Raine; "The Trade of South America," by John E. Bacon; "The Trade and Industries of Russia," by Charlton H. Way; and "The Resources and Trade Relations of Japan," by T. R. Jernigan.

The pamphlet on *Aspects of Education*, by *Oscar Browning* (Industrial Education Association, 20 cents), is a contribution to the history of pedagogy. It discusses the

three modifications of educational theory—humanism, realism, and naturalism—to one or another of which all schemes of instruction that have taken practical form in the last three hundred years may be referred. The essay includes also some remarks on the English public school.

The children will be sure to like *The New Model First Reader* (Sherwood, 35 cents) for its colored pictures, which are supplied with a liberal hand. The mode of teaching to which it is adapted is that known as the sentence-method. It familiarizes the pupil with script as well as with Roman letters.

PUBLICATIONS RECEIVED.

Academy of Natural Sciences of Philadelphia. Proceedings continued. Pp. 24.

Allen, John H. The Tariff and its Evils. New York: G. P. Putnam's Sons. Pp. 122. $1.

Bain, Alexander. English Composition and Rhetoric. Enlarged edition. Part II. Emotional Qualities of Style. New York: D. Appleton & Co. Pp. 325. $1.40.

Baker, Henry B., M. D., Lansing, Mich. The Causation of Cold-Weather Diseases. Pp. 15.—Recent Advances in State Medicine. Pp. 27. The Prevention of the Communicable Diseases. Pp. 7.

Barton, Samuel. The Battle of the Swash and the Capture of Canada. New York: Charles T. Dillingham. Pp. 131. 50 cents.

Berger, François. French Conversations—Idiomatic Expressions—Proverbs. 853 Broadway, New York. Pp. 32. 25 cents.

Brandt, Prof. H. C. G., Hamilton College. Should the Elements of French and German be required for Admission to all Colleges? Pp. 8.—A First Book in German. Boston: Allyn & Bacon. Pp. 87. $1.

Browning, T. B., Toronto. Chart of Elocutionary Drill. Pp. 33.

Calkins, Mary Whiton. Sharing the Profits. Boston: Ginn & Co. Pp. 70.

Cameron, James. Soaps and Candles. Philadelphia: P. Blakiston, Son & Co. Pp. 306. $2.25.

Clokey, Rev. Joseph Waddell. Dying at the Top. Chicago: Woman's Temperance Publishing Association. Pp. 56. 10 cents.

Cope, E. D. Topinard on the Latest Steps in the Genealogy of Man. Pp. 4.

Crozier, John Beattie. Civilization and Progress. London: Longmans & Co. Pp. 447.

Cruger, Mary. How she did it; or Comfort on $150 a Year. New York: D. Appleton & Co. Pp. 212.

Dawson, Sir J. William. Specimens of Eozoon Canadense and their Geological and other Relations. Montreal: Dawson Brothers. Pp. 107. 50 cents.

Evans, George. A Hand-Book of Historical and Geographical Phthisiology. New York: D. Appleton & Co. Pp. 295. $2.

Fletcher, W. Q. "The Co-operative Index to Periodicals." Quarterly. Vol. IV, No. 3. 330 Pearl Street, New York. Pp. 29. 50 cents. $2 a year.

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POPULAR MISCELLANY.

The International Geological Congress.—The fourth session of the International Geological Congress was held in London, beginning September 16th, under the presidency of Prof. Prestwich. The United States was represented in the list of vice-presidents by Prof. Frazer, of Philadelphia. The meeting was the largest in attendance, both of home and foreign geologists, that has been held. It differed from the previous meetings in the point that no votes were taken bearing upon the subjects under discussion; but a report was adopted recommending that in future the members from the country in which the Congress meets shall vote separately from the foreign geologists: if the two groups agree, the question to be considered settled; if not, deferred; and that votes should not be taken on questions that are purely theoretical. The classification of the Cambrian and Silurian strata was fully discussed, and the questions of the nature and origin of the crystalline schists, and of the upper limit of the Tertiary system, were considered in some detail. To the second discussion essays were contributed by five officers of the United States Geological Survey, with an introduction by Major Powell, and by Mr. Lawson, of Canada. The committee on nomenclature and classification has obtained reports from the committees of the different countries, embodying their views on the subject. It now remains to discuss these. Another commission was appointed under the new aspect of the subject, on which Prof. Hall represents the United States. Four or five sheets of the geological map of Europe, relating to central Europe, will be ready for publication within the next two years, and will be given out at once, each with its own title and index, without waiting for the completion of the whole. The Congress decided to hold its fifth meeting, in 1891, in Philadelphia; and Messrs. J. Hall, Dana, Newberry, Frazer, Gilbert, Hunt, Marsh, and Walcott were appointed the committee of arrangements.

Interglacial Man in Ohio.—Until recently it has been a question whether "interglacial" man existed in the Mississippi Valley. Dr. Abbott had even made the suggestion that this race may have lived only in the neighborhood of the sea-coast, and had not spread so far as even to the eastern slope of the Alleghanies. Flint implements palæolithic in character were found in abundance—the work of Indians—but none that could be proved to be of palæolithic age. Some three years ago, however, genuine palæolithic flints were found by Dr. Metz at Madisonville and Loveland, Ohio. The sites of these discoveries have been carefully examined by the Rev. G. F. Wright, who, taking the whole configuration and geological character of the region, with its peculiar formations, into account, pronounces the beds to be unquestionably virgin glacial deposits, in situations where there can have been no subsequent deposition. The discoveries, therefore, show that in Ohio, as well as on the Atlantic coast, man was an inhabitant before the close of the glacial period. A discovery of implements of quartz, situated likewise in gravels and sands that could only be glacial, made by Miss Babbitt at Little Falls, Minn., is confirmed by the researches of Mr. Warren Upham.

Our Indians and the Mongolians.—Dr. Brinton, in a paper read at the American Association, maintained that the resemblances alleged by various writers to exist in language, culture, and physical appearance between American Indians and Mongolians are not supported by recent researches. The

American languages differ entirely from any of the Mongolian group. In culture there are various similarities, but not more and not other than can be pointed out between any two groups of early civilizations, and not one of them is evidence of intercourse. The physical similarities relied upon to show racial affinity begin with the color of the skin. But no American tribe shows the peculiar hue of the Mongol. The hair, although straight in both races, differs in color. The oblique, or Chinese eye, about which much has been said, is by no means usual in the American race, scarcely more so than among the whites, and is, moreover, of less importance than has been maintained. The shape of the skull is markedly different. The Mongolian head is round, that of the Eskimo notably long, and of other tribes mixed. The nasal index of the American Indian approaches that of the modern European much closer than it does the Mongolian. There are in certain tribes some general physiognomical characteristics, and that is all—and this is of little importance.

Religious Notions of Gypsies.—The gypsies' religion, says the author of "The Transylvanian Tziganes," in "Blackwood's Magazine," is of the vaguest description. They generally agree as to the existence of a God, but it is a God whom they can fear without loving. "God can not be good," they argue, "else he would not make us die." The devil they also believe in to a certain extent; but only as a weak, silly fellow, incapable of doing much harm. A gypsy, questioned as to whether he believed in the immortality of the soul and the resurrection of the body, scoffed at the idea. "How could I be so foolish as to believe this?" he asked, with unconscious philosophy. "We have been quite wretched enough, and wicked enough, in this world already. Why should we begin again in another?" Sometimes their confused notions of Christianity take the shape of believing in a God, and in his Son, the young God; but while many are of the opinion that the old God is dead, and that his Son now reigns in his place, others declare that the old God is not really dead, but has merely abdicated in favor of the young God. Though rarely believing in the immortality of the soul, the Tzigane usually holds with the doctrine of transmigration, and often supposes the spirit of some particular gypsy to have passed into a bat or a bird; further believing that, when that animal is killed, the spirit passes back to another new-born gypsy. The gypsies resident in villages and hamlets often nominally adopt the religion of the proprietor of the soil, principally, it seems, in order to secure the privilege of being buried at his expense.

Effects of Cigarette-Smoking.—During a discussion in the American Association, Prof. W. S. Dudley described some experiments which he had made on the injurious effects of cigarette-smoking. He showed that they were principally due to the manner of smoking, and not to the impurities, as is currently supposed. In smoking cigarettes, to get the desired effect, the smoke is inhaled, that is to say it is breathed into the lungs; whereas, in smoking pipes and cigars, the smoke is simply drawn into the mouth and then expelled. In experiments on small animals, in which they were caused to breathe air containing cigarette-smoke, it was found that, after a mouse had smoked one and a fourth cigarette life was extinct. Examination of its blood showed that it had died from the effects of the carbon monoxide which was contained in the smoke, and not from the nicotine and other volatile products of the tobacco and paper. This carbon monoxide is produced by the carbonic-acid gas, which is first formed at the end of the lighted cigarette, passing through the red-hot carbon, while the air is excluded. The smoke of a cigar or pipe, or a Turkish water-pipe, would have the same effect if inhaled.

Development of the Plesiosaurus.—Prof. H. G. Seeley exhibited in the British Association last year a remarkable fossil showing the development of the young of the plesiosaurus. Until this fossil had been discovered and forwarded to him, he had sought throughout the collections of Europe for evidence on that development, but without success. No more remarkable fossil had ever been found, and no incident in the history of fossilization was more singular than that which this specimen displayed. The fossil was a series of mummies of minute plesiosaurs less than five inches in length,

which had the substance of their flesh perfectly preserved, and the bones in place within the flesh. The remains showed different conditions of development. This was the only case that had ever occurred of the mineralization of the muscular substance and the preservation of the external form of these animals; and so perfectly had they kept that the circle of the eye was preserved and the constituent bones could be distinguished.

Hints about Local Museums.—The British Association's Committee on Provincial Museums advises in its report that each such institution ought to be a fully illustrated monograph of its own district. If the entire history of the district and its inhabitants is represented in it, with special attention to any group of objects for which the district is remarkable, this will be almost as much as any local institution can accomplish. But science is daily becoming more exacting in its demands. Details which were thought ample in any provincial museum twenty years ago, would now be regarded as quite insufficient. In order that the scientific statistics of the country may be thoroughly investigated and made known as quickly as possible, a more business-like system of collection should be adopted. The district should be divided into sections, and a paid collector appointed for each of them, whose whole time should be occupied for several years in obtaining specimens and records in every branch of science represented in the museum. This would require a more liberal supply of funds for the first few years than museums usually enjoy, but the value of the museum would be immensely enhanced, and, when the local collections were made tolerably complete, the permanent income required for maintenance would be very much less. The town museum should be the place to which all students and teachers of science in the district would naturally go for assistance.

The Teaching of Chemistry.—The address of Prof. Tilden, as President of the Chemical Section of the British Association, was on the teaching of chemistry. In reviewing the present position of this instruction in England, the author thought the apparent inactivity of the chemical schools was not generally the fault of the professors, but was chargeable in the main to the ignorance, and partly to the indifference, of the public. There exists as yet no intelligent feeling in favor of learning, nor indeed in favor of any sort of education, unless there is expectation of direct returns in the form of obvious practical results. That teachers ought to engage in research at all is by no means clear to the public and to those who are charged with the administration of the new institutions. A popular mistake consists in regarding a professor as a living embodiment of science—complete, infallible, mysterious; whereas, in truth, he is or ought to be only a senior student, who devotes the greater part of his time to extending and consolidating his own knowledge for the benefit of those who come to learn of him, not only what lies within the boundaries of the known, but how to penetrate into the far greater region of the unknown. Moreover, the man who has no intellectual independence, and simply accepts other people's views without challenge, is pretty certain to make the stock of knowledge with which he sets out in life do service to the end. That one may be fitted to form a sound judgment concerning new theories, he must be familiar with the methods by which progress is accomplished. The work of investigation then reacts beneficially upon the work of teaching; that is to say, teachers should be encouraged, nay, even required to investigate, and not because their discoveries may haply prove to be practically useful. Every teacher who has attained eminence as a teacher, who has drawn men after him, who has founded a school of thought, and has left his mark upon his generation, has been an industrious worker in research of some kind.

A Law of Marriage Customs.—With the view of applying direct numerical method to anthropology, Mr. E. B. Tylor has compiled schedules of the systems of marriage among some three hundred and fifty peoples of the world, so as to ascertain by means of a "method of adhesions" how far each rule coexists or not with other rules, and what have been the directions of development from one rule to another. The barbaric custom which forbids the husband and his

wife's parents, though on a friendly footing, to speak to or look at one another, or the converse custom of the wife and her husband's relatives being obliged ceremonially to cut one another, is practiced by some seventy peoples. A marked distinction is found to lie between those peoples whose custom is for the husband to reside with his wife's family, and those where he removes her to his own home. It appears that the avoidance custom between the husband and the wife's family belongs preponderantly to the group of cases where the husband goes to live with his wife's family. This implies a casual connection between the customs of avoidance and residence, suggesting as a reason that the husband, being an interloper in the wife's family, must be treated as a stranger, or not "recognized." Other varieties of the custom show similar preponderant adhesions.

The American Badger.—The mammalian fauna of the United States includes two species of badgers—the American badger (*Taxidea americana americana*) and the Mexican badger (*T. a. berlandieri*), the latter being found on our southwestern border. Dr. R. W. Shufeldt, U. S. A., says that many writers have confounded our species with the European badger (*Meles*), though in reality they are very distinct animals. The American badger is found in this country from Texas, Iowa, and Wisconsin westward, and used to occur much further east. Dr. Shufeldt had a fine one in captivity for a long time at Fort Wingate, and has seen a number of others there, among them being the largest that he ever saw or read about. It was an adult male, and measured from the tip of his nose to the tip of his tail thirty-two inches. Badgers take a varied diet of fruit, birds' eggs, insects, frogs, small mammals, nuts, and roots. It has not been proved that the American badger is as fond of honey as the European species is, and generally its tastes are far more carnivorous. They drink a great deal of water. They spend most of the daytime in the extensive burrows which their enormous fore-claws enable them to excavate, coming out to feed chiefly at night. It is very rare to find a pair of them together. When one has been chased into its burrow it sometimes reappears in a moment or two at the entrance to inspect its pursuer. Dr. Shufeldt has seen Indians take advantage of this habit by running up to the hole and killing the animal with a pistol-shot as it showed its head. Few animals prey upon or molest the badger; it is a strong and determined fighter, and even the wolf and the coyote do not care to attack it. Prof. Elliott Coues, in his "Fur-bearing Animals," says that "the flesh of the badger, like that of the skunk, is eatable, and doubtless often eaten by savage tribes, though not to be recommended to a cultivated palate." Dr. Shufeldt found that the specimens which he skinned emitted during the process a most rank odor. The badger yields a valuable fur. Thousands of shaving-brushes are said to be made annually from the long hairs, from which also the "badger blender" used by artists is made. The colors of the badger pelt are blended gray, tawny, black, and white, the colors ringed in alternation on individual hairs. The gray predominates. Much remains to be observed in regard to the more obscure habits of the badger.

A Phonetic Alphabet for Indian Languages.—Mr. Garrick Mallery, in preparing the phonetic alphabet used by the Bureau of Ethnology in recording Indian languages, while seeking for a distinct character for every sound, made it a fundamental rule that the characters should be limited to those in an ordinary font of English type—including with the Roman alphabet other characters and diacritical marks common in newspaper printers' cases. The range of characters is extended by reversing those letters of the Roman alphabet which look markedly different when reversed. This is entirely convenient to the printer, and does not occasion awkwardness in the current script to the recorder or writer for the press, as he has only to mark the letter intended to be reversed, after writing it in the normal manner, and to notify the printer accordingly. In practice, the letters intended to be reversed are marked by a cross beneath them. The result of this scheme in practice has solved one part of the problem of a universal phonetic alphabet. Vocabularies and chrestomathies of unwritten languages have been recorded and printed, on which

grammars and dictionaries have also been prepared and printed, and from them the languages can be learned so as to be spoken intelligibly without oral instruction.

The Storage of Life.—In an address delivered at the Royal Institution, London, Dr. B. W. Richardson discussed the conditions of the storing or laying up of life, of which the cases of great longevity frequently met with are examples. He puts "hereditary qualification" first of these conditions, and says that the person gifted with this faculty of storage may be of fragile and delicate build, may even be deformed, may be of dull or of bright intellect, may be of cleanly or of uncleanly habit, may be placed in what would seem the most unfavorable position in life, and will continue to live on so as to see all of his more fortunate neighbors fall. The two hereditary temperaments which are incompatible with storage of life are the nervous and the lymphatic; the two which are compatible, and perhaps necessary, are the sanguine and the bilious; better, perhaps, than any singly, would be a mixture of the two latter. In the organism best constituted for storage, the color of the eyes, always an excellent test, is a light hazel, the hair is dark brown, the color of the skin is inclined to be florid, and the lips and eyelids are of good natural red. Dr. Richardson is confident that the number of persons who reach the classical threescore years and ten in England at present is much above what it has ever been in the history of the country. Toward improving heredity in the direction of longevity, the first consideration is the selection of lives for parentage. If such a social miracle could be performed as the fashion of a proper arrangement to prevent the marriage of health with disease, or, still more urgently, the intermarriage of disease, there would soon be an important advance in the value of life. A strong aid to the force of heredity is the virtue of continency, or that virtue which would provide for the limitation of the family circle to such a degree that the resources of the family may never be dangerously taxed by the largeness of it. Another aid is rendered by the art of training the body in such form that all parts of it shall be kept in perfect balance and in equal health. "I do not remember," says Dr. Richardson, "any one of fine and vigorous frame of body and mind who, dying prematurely, did not die from the failure of some one vital organ almost exclusively." A weak and well-balanced body is practically a stronger body than a strong and unbalanced one, and a body of original strength and beauty may be made of unusually long or of unusually short life, according as it is trained into the conditions leading to the one or the other. The storage of life is promoted also by that stoical virtue which may be summed up in the term perfected or all-round temperance. I include in this term not merely abstinence from stimulating or alcoholic drinks. The storage of life is reduced by intemperance of speech, of action, and even of thought. We may consider that whatever quickens the action of the heart beyond its natural bounds is a form of intemperance. The wild hope or wilder despair of the money-market, unbridled passion, and jealousy, are among the kinds of stimulation that hasten the decline of heart-power. The existence among men of diseases which lead to physical deterioration, and reduce the capacity for the storage of life, not alone in one but through many generations, is the last subject to which there is time to refer. The alcoholic diseases, the scrofulous and phthisical, the malignant or cancerous, the syphilitic, are diseases of this order, and whoever helps to remove them by getting at and removing their causes is among the truest friends that humanity ever possessed.

Protection of Wood against Fire.—An investigation has been made by Profs. Boudin and Donny, of the Ghent University, at the requisition of the Belgian Minister of Public Works, in regard to rendering wood uninflammable. They reported that to deprive wood to a considerable extent of the property of catching and communicating fire it is sufficient to coat it with a suitable composition. A practical process must not be too expensive, nor take too much time, and the substance used must not attack any metal used in connection with the wood. Two methods of treatment may be mentioned. One is the injection of saline solutions, which appears but little applicable except to small pieces of wood, and may be

dangerous in the case of wood of large dimensions. A concentrated solution of phosphate of ammonia, although expensive, is undoubtedly the best substance to apply by injection. Certain substances, notably chloride of calcium, should be rigorously excluded, because they would keep the wood constantly damp. This method may be applied to small articles by immersion, and the solution should be hot. In the majority of cases, including existing structures, applying some coating with a brush is the only practicable treatment. The wood thus coated should present a neat appearance, should be capable of receiving a coat of ordinary paint, nor should either coating deteriorate within a moderate time. The best substances for such application are cyanide of potassium and asbestus paint.

Tests of Eye-Sight, Hand-Grip, and Breathing Capacity.—Some curious observations on men and women were reported from the Anthropometric Laboratory at Manchester to the British Association. Of members of the association who were tested at the museum for keenness of eye-sight, the men could see diamond type with their right eye at a distance of 19·6 inches, and with their left eye at a distance of 18·2 inches, showing a distinct difference between right and left. A similar difference was manifested among the women, who with their right eye saw at a distance of 19·2 inches, and with the left at a distance of 18·7 inches. The men averaged 41·7 years of age, and the women were between 23 and 25 years. In no case could one see (diamond type) more than 34 inches with the right eye, but with the left one could see beyond that distance. Among 102 men and 98 women, the right eye was equal to the left in 26 instances in the men and 31 in the women; in 35 instances among the men and 28 among the women the right eye could see further than the left, and in 24 cases in the men and 28 in the women the right eye was worse than the left. The strength of the squeeze showed that it was not uncommon to find a difference of 5 or 6, or even 10 pounds between the squeezing power of the two hands. The average squeeze of the men was between 35 and 45 kilos, and that of the women about 25 kilos. The average weight of the men was between 11 and 12 stone, and that of the women about two stone less; the height of the men 68 inches, and of the women 4 inches less. Speaking of the effects of stays, which Dr. Garson said interfere with the abdominal respiration, Mrs. Stokes observed that the statistics of the stay and corset makers and sellers of London showed that the average size of the female waist had decreased during the last twenty-five years by two inches. Concerning the breathing capacity of some who wore no stays, Dr. Wilberforce Smith said that one woman 59 inches in height, whose breathing capacity, according to the usual average, should be 100, had an actual capacity of 135; another, whose average should be 115, had actual 158; a third, average 130, actual 150; a fourth, average 130, actual 200; a fifth, average 162, actual 195. In one person, in feeble health, the actual was less than the average.

The Chinese and their Limbs.—The Chinese, according to the "North China Herald," are opposed to having amputations performed upon them, not because they are afraid of the pain, but because they look upon it as a duty to keep the body intact. If they submit to it, they ask for the severed member, and keep it in a box, to be buried, in due time, with the owner. Sometimes they will eat it, in the thought that it is right that that which has been taken from the body should be returned to it. So an extracted tooth will be preserved, or ground to powder and swallowed in water. They also have a notion that a sick parent can be cured by broth made from flesh cut from a living child, and it is looked upon as a sign of filial piety for a child to submit himself to an operation for that purpose. The child is supposed to be of the vital essence of the parent, and it is thought that, if a part of this essence is returned to the fountain-head, the parent will be greatly strengthened.

Water-Storage at River-Heads.—Mr. J. Bailey Denton proposed, in the British Association, a plan for replenishing the subterranean supplies of the underground strata by means of shafts to be sunk down to the line of their saturation. He computes that of the twenty-seven inches forming the mean

annual rainfall, about two thirds, or eighteen inches, are evaporated from the surface, while of the remaining third, four inches serve to maintain the river systems, and five inches pass away as floods and freshets. As the amount of evaporation is nearly a constant figure, and the quantity required to maintain effectually the river system necessarily remains the same under all conditions, the amount of flood or excess of water greatly varies. To make good the loss of this surplus water, the author proposes that whenever the water in the river rises above a certain datum height recognized as the gauge of its full service, the excess shall be diverted out of the river-course on to filter-beds formed near at hand. The outlet from these filter-beds would be steined shafts or sumps sunk down to the water-level beneath, and into them the filtered water would pass after it was freed from flocculent matter. The steined shafts would be made water-tight and sealed against all surface contamination.

Monopolies.—In a British Association paper on "The Growth of Monopoly, and its Bearing on the Functions of the State," Prof. H. S. Fox well pointed out that, whereas the general expectations of Adam Smith and his contemporaries were that the reforms they advocated would introduce an era of free competition and abolish monopoly, a century's experience had shown us that they had merely shifted the basis on which monopoly rested, and given it a secure seat. Liberty had not led to equality. Competition was a transitional, not a permanent stage. It merely substituted for monopoly based on privilege monopoly based on natural selection. All the most characteristic tendencies of the age favor the growth of monopoly. Monopolies thus arising were free from many of the defects of the old monopolies, and presented advantages over a state of unmitigated competition. But they had their special dangers, and required appropriate forms of state control. There need be an extension of the objects and principles of state control as generally indicated by Adam Smith and Mill. Whatever might be the case under a competitive system, monopolies could not be wholly self-regulating. The modern question was no longer between *laissez faire* and legislation, but between regulation and collecticism.

The Telephone Two Hundred Years ago.—How rare it is to discover anything that is entirely new is freshly exemplified to us in what Robert Hooke wrote about what has become the telephone, as far back as 1664, or two hundred and twenty-four years ago. He said: "And as glasses have highly promoted our seeing, so it is not improbable but that there may be found many mechanical inventions to improve our other senses, of hearing, smelling, tasting, touching. 'Tis not impossible to hear a whisper a furlong's distance, it having been already done; and perhaps the nature of the thing would not make it more impossible, though that furlong should be ten times multiplied. And though some famous authors have affirmed it impossible to hear through the thinnest plate of Muscovy glass, yet I know a way by which it is easy enough to hear one speak through a wall a yard thick. It has not yet been examined how far octocoustics may be improved, nor what other ways there may be of quickening our hearing, or conveying sound through other bodies than the air; for that is not the only medium. I can assure the reader that I have, by the help of a distended wire, propagated the sound to a very considerable distance in an instant, or with as seemingly quick a motion as that of light; at least, incomparably swifter than that which at the same time was propagated through the air; and this not only in a straight line, or direct, but in one bended in many angles."

The Destructive White Ant.—There is something terrible in the destruction which the white ant, or termite, is capable of inflicting on whatever articles of wood it attacks. There is, at the South Kensington Museum, what is left of a heavy, square door-lintel of teak-wood, after the ants had operated on it at St. Helena. It was reduced to a mere skeleton of the heart-wood, looking like a gnarled and knotty smaller limb. Mr. John R. Coryell relates, in the "Scientific American," that he once, in southern China, attempted to have a large hard-wood chest filled with books removed. When the men tried to lift it by the iron handles, it all crumbled and fell to the floor, a heap of dust and splinters; and the books were in the same condition. The ants are

even dangerous to metals, and a piece of lead is exhibited at South Kensington which has been eaten into holes by them. Only camphor will keep them away. The destructive powers last during the whole life of the ant, and are exercised, in nearly equal degree, in the stages of larva, pupa, and perfect insect. The termites are extremely productive, and, were it not that they are very easily destroyed, might soon possess the world. One female will lay in the neighborhood of thirty-one million eggs in the course of the year. The males and females are endowed with wings at the pairing-season, when they sometimes fill the air in their flight. The majority of them lose their lives at that time, else they would multiply so as to make other existence intolerable. The females which are not destroyed are taken in hand by "workers," and imprisoned in a large cell, where they lay their eggs, at the rate of eighty thousand a day, which are at once taken by the "workers" to their particular cells. The female holds within her body, when pregnant, all the eggs she is ever going to lay, and there are thirty-one millions of them. The effect of breeding so enormous a mass is to swell her body so that, when she begins to lay, she will weigh a thousand times as much as when she took her pairing-flight. The wood-eating termite makes its home underground, and approaches the object it is going to consume by tunneling to it. Usually it follows the grain of the wood, or whatever course may be most convenient; and sometimes it fills the hollow shell from which it has eaten the substance with a packing of mud; and thus it happens that posts, etc., which the ant has eaten, do not give way. In all its operations it shows high intelligence and a genius for contrivance.

African Roads.—According to Colonel Sir C. W. Wilson, the roads over which the land trade of equatorial Africa now passes from the coast to the interior are mere footpaths, described by Prof. Drummond in his book on "Tropical Africa" as being never over a foot in breadth, beaten as hard as adamant, and rutted beneath the level of the forest-bed by centuries of native traffic. "As a rule, these footpaths are marvelously direct, running straight through everything, ridge and mountain and valley, never shying at obstacles, never turning aside to breathe. Yet within this general straightforwardness there is a singular eccentricity and indirectness in detail. Although the African footpath is, on the whole, a bee-line, not fifty yards of it are ever straight. And the reason is not far to seek. If a stone is encountered, no native will ever think of removing it. Why should he? It is easier to walk around it. The next man who comes that way will do the same. . . . Whatever the cause, it is certain that, for persistent straightforwardness in the general, and utter vacillation and irresolution in the particular, the African roads are unique in engineering. No country in the world is better supplied with paths; every village is connected with some other village, every tribe with the next tribe; and it is possible for the traveler to cross Africa without being once off a beaten track."

Educational Value of Phonetic Spelling.—Mr. Isaac Pitman, in a paper on economy in education and in writing, stated to the British Association that a million pounds yearly are wasted by the present method of teaching reading in the English elementary schools. The first occupation of children in schools is to learn to read, and they spend, at the lowest reckoning, eight hours a week, during the first four years of their school-life, in gaining a certain amount of reading power. An equal degree of proficiency might be gained by using phonetically printed books during the first two years, and by reading in the present books afterward. The cost of teaching reading to the children in the elementary schools is about two million pounds. One half of this sum would be saved by the use of an alphabet containing a letter for each sound in the language. As reading is now taught, the sound or pronunciation of every word has to be learned independently of the names of the letters that compose it, and generally in spite of the names or sounds of the letters; but, by the use of letters that make up the sound of a word, certainty and celerity in the art of reading take the place of doubt and difficulty. In the discussion on this paper, Dr. J. H. Gladstone said that children should be taught the properties and attributes of things in nature surrounding

them, before they were taught mere intricacies of language, so that the child should be thoroughly educated in mind, body, and soul. He rejoiced to find that there was a great advance in the direction of spelling reform, because it was now being found out that our present system was productive of enormous expense, difficulties, and wasted energy.

An Eyeless Child.—A girl thirteen years of age has been exhibited by Dr. Menacho, at the Cataluña Academy of Medical Sciences, in whom, while the eyelids, lachrymal apparatus, and orbits appeared to be well formed, there was no eye on either side, but in its place a simple cavity could be seen on separating the eyelids. This cavity was invested by the conjunctiva, which apparently rested on some firm fibrous basis, in which movements could be detected, as if there were rudiments of the ocular muscles. In the thickness of both inferior eyelids a kind of bursa or cyst could be felt, that on the left side being the larger and having a whitish coat like the sclerotic, which could be seen through the conjunctiva posteriorly, where it was thin and transparent. This became tense during crying, and the child was observed to press it frequently with her hands, and then to smile. It is supposed that a subjective sensation of light was thus produced.

NOTES.

THE first part of Prof. Topinard's paper on "The Last Stages in the Genealogy of Man," the conclusion of which is given in this number of the "Monthly," was published in the October number. The remainder of the paper was omitted from the November number, in which it should regularly have appeared, on account of the pressure of matter claiming insertion.

PROF. W. H. FLOWER has been chosen President of the British Association for next year. The meeting will be held at Newcastle-on-Tyne, and the meeting for 1890 will be held at Leeds.

LOCUSTS, which are a great nuisance there, are trapped in Cyprus by means of a screen of canvas having at the top a strip of smooth oil-cloth up which the insects can not crawl. They are thus compelled to creep along the screen and fall into holes, from which their exit is prevented by a somewhat similar contrivance. They are then buried. The system has been very successful, and gives hope that the locusts may ultimately be exterminated. Birds are also effective in destroying the pests. Canon Tristram tells of an instance in which a mass of locust-grubs so thick as to cover the ground was entirely devoured in a very short time by a certain species which followed them in large flocks.

MR. E. B. POULTON reports to the British Association every two years his observations upon a family of many-toed cats, of which he has individuals down to the tenth generation. They originated from a cat named Punch, which had six toes on each foot. The peculiarity appeared with more or less modification in a large number of his descendants, some of which had seven toes on each foot.

ACCORDING to Sir John Lubbock, about 4,500 species of wild bees are known, and 1,100 of wasps, of which 170 and 16 respectively live in Britain. Their habits differ in almost every genus, and some offer points of great interest. The amophilla, having built her nest, places in it as food for the young a full-grown moth. This must be prevented from escaping, yet must not be killed; the wasp paralyzes it by a series of carefully adjusted stings, and crushes its head, leaving it alive, but without the power of motion. There appears to be some evidence that the mother-wasp can control the sex of the egg. Sir John mentions the death of a queen-ant which had lived in one of his nests since 1874, and must therefore have been fourteen years old, much the oldest insect on record.

A NEW view of the value of the study of anthropology, as popularized in such a museum as he would design, is given by Lieutenant-General Pitt-Rivers, in his address at the British Association. He says: "It would adapt itself more especially to the limited time for study at the disposal of the working-classes, for whose education . . . we are all most deeply concerned. Anything which tends to impress the mind with the slow growth and stability of human institutions and industries, and their dependence upon antiquity, must contribute to check revolutionary ideas."

COPENHAGEN was visited by a blizzard at about the same time that our Atlantic coast was suffering from the affliction. It began on the 10th of March and continued to the 13th, piling up the snow to fabulous heights, and accompanied with intense cold. The city was wholly cut off from surrounding districts. The straits between Sweden and the Danish islands were at the same time covered with a tolerably thick ice. It is a curious coincidence that in 1788 the snow fell so deep in Scandinavia that it had not wholly disappeared in the following June.

A RACE between bees and pigeons took place at Hamme, Westphalia, in July, 1888. Twelve bees, having been rolled in flour to mark them, and twelve pigeons belonging to a fancier in the village, were let loose at Rhynern, about a league away. The first bee reached home a quarter of a minute before the first pigeon, and the rest of both squads arrived at the same instant a few moments afterward.

ONE of the most obvious benefits of the present popularity of out-door games, like lawn-tennis, among women, is that it will compel attention to the provision of more free-fitting and hygienic dress. These games can not be played with tight-fitting and peg-heeled shoes. Hence, looser shoes with reasonable heels are worn for this game, and are coming into more general use for ordinary wear. Loose-fitting robes are also necessary in lawn-tennis, and their advantages for other occupations are likewise becoming apparent.

ACCORDING to Prof. Oliver J. Lodge, the two main destructive aspects of a lightning-flash are its disruptive or expanding or exploding violence, and its heat. The heating effect is more to be dreaded when the flash is slow and much resisted; the bursting effect when conducted well, except at a few places. A noteworthy though obvious thing is, that the energy of the discharge must be got rid of somehow. The question is, how best to distribute it. The disruptive result is well shown by the effect of lightning on trees. It is as if every cell were burst by the expansion in the path of the discharge. The effect on conductors is, however, just as marked.

ARSENIC is still too freely used in goods designed for the decoration of rooms. What might have proved a serious epidemic if the goods had not been removed was started recently in a civil-engineering college in England from the brilliantly colored cretonne and muslin hangings of some of the students' rooms. Even such colors as black and dark blue, in which the presence of arsenic is not likely to be suspected, have sometimes been found unsafe.

THE order of the Rising Sun has been conferred by the Mikado on Prof. John Milne, of the Imperial University of Tokio, Japan.

A CASE is reported by H. Mallins, in which a skin-disease was transmitted from a cow to a family of children who used the milk. In the cow the disease took the form of a rash, mostly dry, all over the body. In the children it showed itself first in small, blister-like vesicles on the tongue and mucous membrane of the mouth, followed in three weeks by a limited number of vesicular eruptions on various parts of the body, which formed sores and left dark-red scars.

A SURVEY of the Nicobar Islands has been made by Colonel Strahan, of the India Survey. The total area of the group is 618 square miles, and its culminating point is 2,105 feet above the sea. The scenery is of "indescribable beauty." Several rivers are navigable by boats for some miles, of which the Galatea, fringed with a luxuriant tropical vegetation and presenting occasional glimpses of distant mountains, runs through a region only sparsely inhabited, by a tribe so utterly barbarous as to be despised by their fellow-barbarian Nicobarese of the coasts. The inhabitants as a rule are allied to the Malays, of good physical development and a reddish-brown color, are unconquerably lazy, and show great talent for learning languages.

IT has been observed that pure sesquioxide of iron, added in small quantities to carbonate of lime, communicates to it the property of fluorescence after calcination in the air.

THE British Registarar-General has published statistics bearing upon the increase in the death-rate from cancer during thirty-five years, and upon the geographical distribution of the disease. The increase in England and Wales in the ten years 1871–'80, as compared with the decade 1851–'60, was equal to sixty-two per cent among male and forty-three per cent among female patients. Cancer appears to prevail most extensively in London and its environs—possibly by reason of the attractions offered to patients by its hospitals—and in Devonshire—possibly on account of the health-resorts.

THE English "Sporting and Dramatic News," while it admits the desirability of revising the rules of foot-ball so as to make it less rough and dangerous, pleads for the retention of the sport, because it is essentially a poor man's game. It needs no costly outfit, and does not call for very serious traveling expenses. But for the very reason that the bulk of foot-ballers are, comparatively speaking, poor men, they should be as exempt as possible from injury, for they can not afford to be laid up.

THE process of unliming hides and skins in tanning has been a slow and disgusting one, consisting in soaking the skins in a bath of manure in water, called *bate*. A new method comes from Australia, and consists simply in utilizing the power of dissolving lime possessed by water charged with carbonic-acid gas. The process has been patented and applied in England. A half-hour's soaking in the carbonic-acid bath is said to cleanse the skins so thoroughly that after scraping they absorb the tan with extreme readiness, and yield a very flexible and fine-grained leather. The inventor computes that at least one third of the time of leather-making is saved by his process.

A LITTLE drowsiness is natural to the work of digestion, and may be taken as a fair indication of its activity; but normally it should be no more than can be overcome by an easy diversion. When the tendency to sleep regularly follows a meal and is well marked, it must be explained in some other way—perhaps by excess of food, or some special bodily condition. The effect of actual sleep on digestion can not be immediately helpful, for, during its continuance, all the bodily operations are slower, but a good effect may possibly follow in the greater energy of life after a little rest. Persons who sleep after eating should take account of the fact in fixing the hour for the next meal.

AN English brewer, recently deceased, Mr. Richard Berridge, has left a fund of £200,000, or $1,000,000, to be applied to the advancement of economic and sanitary science.

IT is remarked, in connection with the active sanitary measures that have been set on foot in Japan since the cholera epidemic of 1886, that the people themselves have come largely to appreciate the importance of sanitation, and the work is going on "smoothly between the authorities and the people, without the least misunderstanding or ill feeling."

A PIECE of dry biscuit has been found by W. J. Russell to possess an odor which could be perceived by a pug dog at a distance of several inches, when hidden and covered up, and even when its smell was disguised by cologne-water. In every instance the dog, when called in, was able to find the biscuit in less than a minute.

A STORY is told in the north of England papers of a person, who, having had his right eye destroyed and his frontal bone broken by an explosion, and lost also the vision of his left eye, from shock to the retina, it is supposed, had his vision restored by lightning. During a severe thunder-storm he remarked that he saw light through his spectacles, and immediately afterward experienced a piercing sensation passing from his eye to the back of his head, after which he found that he could see indistinctly the objects near him. The next day he was able to walk about the town without a guide.

THE nations which still eat with the fingers defend the practice on the ground of cleanliness. A Malay gentleman regards the use of a fork much as we should think of the use of a borrowed tooth-pick. He is troubled by the reflection that it has been in other mouths, and that some lazy servant may have neglected to wash it properly. The care of his fingers is in his own charge, and he knows that they are clean, and that they have never been in any one else's mouth.

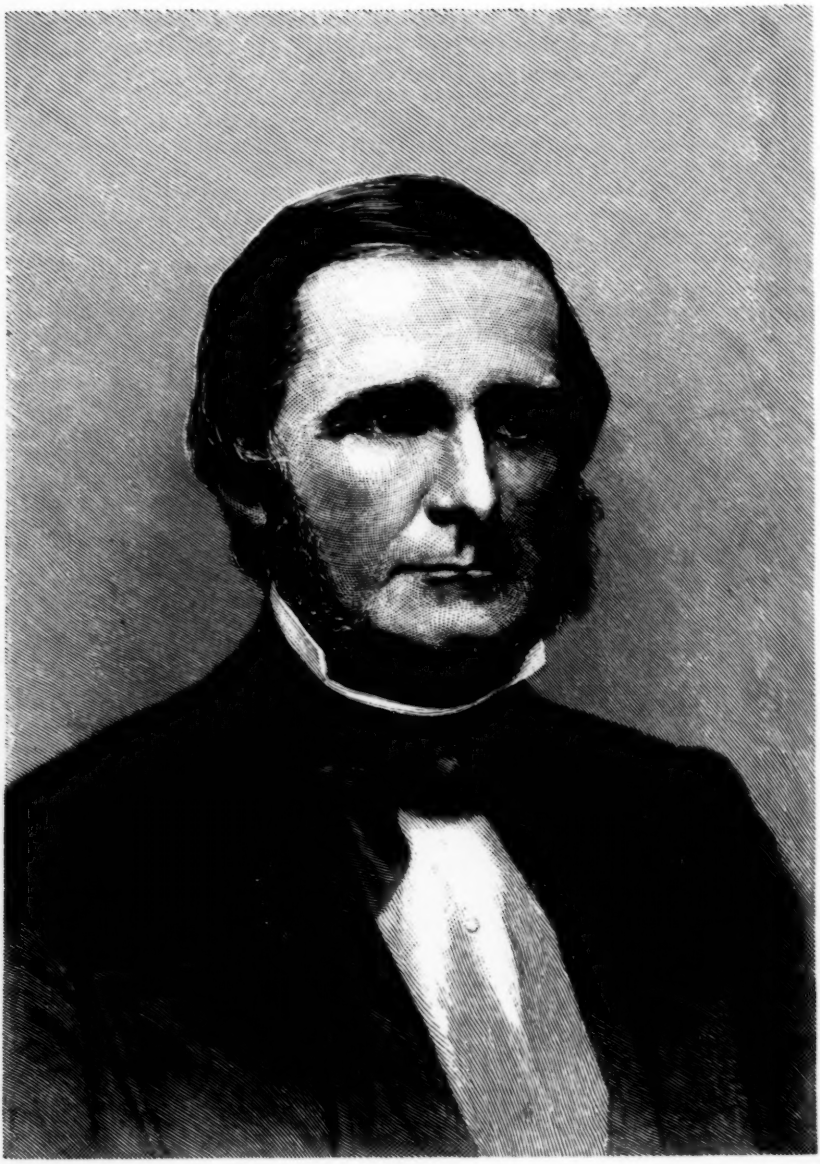
THE statistics of blindness in Russia go to show that the affliction prevails more widely among the Ural-Altayans, and especially among the Finnish-Mongolian stems, than among the Aryans and Shemites, although the conditions of these races, so far as poverty is concerned, are much the same. One eighth of all the cases are due to small-pox, and one half only to direct eye-diseases.

IT is said that the ivory produced by eight hundred elephants is consumed every year by a single firm only—Messrs. Rodgers and Sons, cutlers, of Sheffield.

DR. DEFONTAINE, of the Creuzot steel-works, has described an affection which he calls electric sunstroke, to which the workmen in that factory are subject. The electric furnace, which is essentially an arc-light of 100,000 candle-power, produces upon the workmen all the symptoms of sunstroke. Although protected by dark glasses, the retina of the eye is painfully affected, the sight is very considerably disturbed, a copious discharge of tears is kept up, headache and sleeplessness are engendered, and the skin of the face peels off.

IT is quite generally known that the correction which each astronomer has to make to his observations, called his "personal equation," represents the slight delay which occurs after his eye observes an event and before his hand records it. The time required for the passage of a nervous impulse from the retina to the brain, its translation there into terms of consciousness, the sending of an efferent nervous impulse to the hand, and the setting in motion the muscles which move the recording-instrument, differs in different persons—hence the personal nature of the correction. It is not so well known, however, that the personal equation of an observer is determined, not with reference to the actual time of the event, but with reference to the time as observed by some particular observer, who is taken as a standard, his equation being arbitrarily assumed to be zero. Hence it sometimes occurs that a personal equation is a minus quantity, but this does not signify that the observer anticipates events, it shows only that he loses less time than the standard man with whom he is compared.

THE doctrine that cold or chill is a general cause of such diseases as bronchitis, pneumonia, pleurisy, and rheumatism, is disputed by Dr. W. H. Ransom, of Nottingham. While admitting that such diseases are apt to appear during cold seasons and in cold or temperate latitudes, he has failed to observe such a direct correspondence between the chill and the disease as would satisfy him of the existence of a valid relationship of cause and effect; and he is disposed to regard the chill as a coefficient of the cause rather than the primary excitant itself.



MOSES ASHLEY CURTIS.